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A. Compliance Forms

Envelope Forms

CERTIFICATE OF COMPLIANCE (Part 1 of 2) ENV-1

PROJECT NAME		DATE
PROJECT ADDRESS		
PRINCIPAL DESIGNER-ENVELOPE	TELEPHONE	Building Permit #
DOCUMENTATION AUTHOR	TELEPHONE	Checked by/Date Enforcement

GENERAL INFORMATION

DATE OF PLANS	BUILDING CONDITIONED FLOOR AREA		CLIMATE ZONE
BUILDING TYPE	☐ NONRESIDENTIAL	☐ HIGH RISE RESIDENTIAL	☐ HOTEL/MOTEL GUEST ROOM
PHASE OF CONSTRUCTION	☐ NEW CONSTRUCTION	☐ ADDITION ☐ ALTERATION	☐ UNCONDITIONED (file affidavit)
METHOD OF ENVELOPE COMPLIANCE	☐ COMPONENT	☐ OVERALL ENVELOPE	☐ PERFORMANCE

STATEMENT OF COMPLIANCE

This Certificate of Compliance lists the building features and performance specifications need to comply with Title 24, Parts 1 and 6 of the California Code of Regulations. This certificate applies only to building envelope requirements.

The documentation preparer hereby certifies that the documentation is accurate and complete.

DOCUMENTATION AUTHOR	SIGNATURE	DATE

The Principal Envelope Designer hereby certifies that the proposed building design represented in this set of construction documents is consistent with the other compliance forms and worksheets, with the specifications, and with any other calculations submitted with this permit application. The proposed building has been designed to meet the envelope requirements contained in sections 110, 116 through 118, and 140, 142, 143 or 149 of Title 24, Part 6.

Please check one:

- ☐ I hereby affirm that I am eligible under the provisions of Division 3 of the Business and Professions Code to sign this document as the person responsible for its preparation; and that I am licensed in the State of California as a civil engineer or mechanical engineer, or I am a licensed architect.
- ☐ I affirm that I am eligible under the provisions of Division 3 of the Business and Professions Code by section 5537.2 or 6737.3 to sign this document as the person responsible for its preparation; and that I am a licensed contractor performing this work.
- ☐ I affirm that I am eligible under Division 3 of the Business and Professions Code to sign this document because it pertains to a structure or type of work described as exempt pursuant to Business and Professions Code Sections 5537, 5538 and 6737.1.

(These sections of the Business and Professions Code are printed in full in the Nonresidential Manual.)

PRINCIPAL ENVELOPE	SIGNATURE	DATE	LIC. #

ENVELOPE MANDATORY MEASURES

Indicate location on plans of Note Block for Mandatory Measures ____________________

INSTRUCTIONS TO APPLICANT

For Detailed instructions on the use of this and all Energy Efficiency Standards compliance forms, please refer to the Nonresidential Manual published by the California Energy Commission.

ENV-1: Required on plans for all submittals. Part 2 may be incorporated in schedules on plans.

ENV-2: Used for all submittals; choose appropriate form depending on method of envelope compliance.

ENV-3: Optional. Use if default U-factors are not used. Choose appropriate form for assembly U-factor to be calculated.

CERTIFICATE OF COMPLIANCE (Part 2 of 2) ENV-1

PROJECT NAME	DATE

OPAQUE SURFACES

Surface Type	Type (e.g., Block, Wood, Metal)	Area	U-factor	Azimuth	Tilt	Solar Gains Y/N	Form 3 Reference	(e.g., Suspended Ceiling, Demising, etc.)	For Building Dept. Use Only
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			

FENESTRATION SURFACES

Site Assembled Glazing

☐ Check box if Building is ≥ 100,000 ft^2 of CFA and ≥ 10,000 ft^2 of vertical glazing then NFRC Certification is required. Follow NFRC 100-SB Procedures and submit NFRC Label Certificate Form. See Section 10-111

Fenestration Type	Area	U-factor	Azimuth	SHGC	Glazing Type	Location / Comments	NOTES TO FIELD – For Bldg. Dept. Use Only

EXTERIOR SHADING

Fenestration #	Exterior Shade Type	SHGc	Window		Overhang				Left Fin			Right Fin		
			Height	Width	Length	Height	Lext.	Rext.	Dist.	Length	Height	Dist.	Length	Height
		Performance Use Only							Performance Use Only	Performance Use Only	Performance Use Only	Performance Use Only	Performance Use Only	Performance Use Only

NOTES TO FIELD – For Building Department Use Only

ENVELOPE COMPONENT METHOD ENV-2

PROJECT NAME	DATE

WINDOW AREA CALCULATION and SKYLIGHT AREA CALCULATION

GROSS WALL AREA (GWA)		DISPLAY PERIMETER (DP)	
GWA x 0.40		DP x 6	

GREATER OF

MAX. ALLOWABLE

If the PROPOSED WINDOW AREA is greater than the MAXIMUM ALLOWABLE WINDOW AREA, go to another method.

PROPOSED WINDOW AREA

Window Wall Ratio = Proposed Window Area Divided by Gross Exterior Wall Area

ATRIUM HEIGHT ______ FT

IF ≤ 55 FT IF > 55 FT

0.10	x		=	
0.05	x		=	
		GROSS ROOF AREA		ALLOWED AREA

If the ACTUAL SKYLIGHT AREA is greater than the ALLOWED SKYLIGHT AREA, go to another method. ACTUAL SKYLIGHT AREA

OPAQUE SURFACES

ASSEMBLY NAME (eg. Wall-1, Floor-1)	TYPE (eg. Roof, Wall, Floor)	HEAT CAPACITY	INSULATION R-VALUE*		ASSEMBLY U-FACTOR*			
			PROPOSED	MINIMUM ALLOWED	PROPOSED	TABLE VALUES? Y	TABLE VALUES? N	MAXIMUM ALLOWED
						☐	☐	
						☐	☐	
						☐	☐	
						☐	☐	
						☐	☐	

* For each assembly type, meet the minimum insulation R-value or the maximum assembly U-factor.

WINDOWS

WINDOW NAME (e.g., Window-1, Window-2)	ORIENTATION				U-FACTOR		# OF PANES	PROPOSED RSHG						ALLOWED RSHG
	N	E	S	W	PROP.	ALLOW.		SHGC	H	V	H/V	OHF	PROP. RSHG	
	☐	☐	☐	☐										
	☐	☐	☐	☐										
	☐	☐	☐	☐										
	☐	☐	☐	☐										

SKYLIGHTS

SKYLIGHT NAME (e.g., Sky-1, Sky-2)	GLAZING			# OF PANES	U-FACTOR		SOLAR HEAT GAIN COEFFICIENT	
	With Curb	With No Curb	Plastic		PROPOSED	ALLOWED	PROPOSED	ALLOWED
	☐	☐	☐					
	☐	☐	☐					
	☐	☐	☐					
	☐	☐	☐					

OVERALL ENVELOPE METHOD (Part 1 of 6) ENV-2

PROJECT NAME	DATE

WINDOW AREA TEST

A. DISPLAY PERIMETER		FT × 6 =		SF DISPLAY AREA
B. GROSS EXTERIOR WALL AREA		SF × 0.40 =		SF 40% AREA
C. GROSS EXTERIOR WALL AREA		SF × 0.10 =		SF MINIMUM STANDARD AREA
D. ENTER LARGER OF A OR B				SF MAXIMUM STANDARD AREA
E. ENTER PROPOSED WINDOW AREA				SF PROPOSED AREA

F. WINDOW WALL RATIO = Proposed Window Area Divided by Gross Exterior Wall Area = ______

IF E IS GREATER THAN D OR LESS THAN C, PROCEED TO THE NEXT CALCULATION FOR WINDOW AREA ADJUSTMENT. IF NOT, GO TO PART 2 OF 6.

1. IF E IS GREATER THAN D:

MAXIMUM STANDARD AREA		PROPOSED WINDOW AREA		WINDOW ADJUSTMENT FACTOR
	÷		=	

GO TO PART 6 TO CALCULATE ADJUSTED AREAS

2. IF LESS THAN C:

MINIMUM STANDARD AREA		PROPOSED WINDOW AREA (IF E = 0 ENTER 1)		WINDOW ADJUSTMENT FACTOR
	÷		=	

GO TO PART 6 TO CALCULATE ADJUSTED AREAS

SKYLIGHT AREA TEST

______ FT

OR

IF ≤ 55 FT IF > 55 FT

STANDARD %		GROSS ROOF AREA		STANDARD SKYLIGHT AREA
0.10	x		=	
0.05	x		=	

PROPOSED SKYLIGHT AREA ______

IF THE PROPOSED SKYLIGHT AREA IS GREATER THAN THE STANDARD SKYLIGHT AREA, PROCEED TO THE NEXT CALCULATION FOR THE SKYLIGHT AREA ADJUSTMENT. IF NOT, GO TO PART 2 OF 6.

1. IF PROPOSED SKYLIGHT AREA ≥ STANDARD SKYLIGHT AREA:

STANDARD SKYLIGHT AREA		PROPOSED SKYLIGHT AREA (IF E = 0 ENTER 1)		SKYLIGHT ADJUSTMENT FACTOR
	÷		=	

GO TO PART 6 TO CALCULATE ADJUSTED AREAS

OVERALL ENVELOPE METHOD (Part 2 of 6) ENV-2

PROJECT NAME	DATE

OVERALL HEAT LOSS

	A		B	C	D			E	F	G	H
			PROPOSED						STANDARD		
	ASSEMBLY NAME (e.g. Wall-1, Floor-1)		AREA	HEAT CAPACITY	U-FACTOR	TABLE VALUES? **Y**	**N**	UA (B × D)	**AREA*** (Adjusted)	U-FACTOR	**UA** (F × G)
WALLS						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
ROOFS/CEILINGS						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
FLOORS/SOFFITS						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
WINDOWS		# OF PANES		N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
SKYLIGHTS		# OF PANES		N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				

* If Window and/or Skylight Area Adjustment is required, use adjusted areas from part 6 of 6.

TOTAL ◄ Column **E** shall be no greater than Column **H** ► TOTAL

OVERALL ENVELOPE METHOD (Part 3 of 6) ENV-2

PROJECT NAME	DATE

OVERALL HEAT GAIN FROM CONDUCTION

	A		B	C	D	E			F	G	H	I	J
			PROPOSED							STANDARD			
	ASSEMBLY NAME (e.g. Wall-1, Floor-1)		AREA	TEMP. FACTOR	HEAT CAPACITY	U-FACTOR	TABLE VALUES? Y	N	HEAT GAIN (B ×C ×E)	AREA* (Adjusted)	U-FACTOR	TEMP. FACTOR	HEAT GAIN (G ×H ×I)
WALLS							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
ROOFS/CEILINGS							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
FLOORS/SOFFITS							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
WINDOWS		# OF PANES			N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
SKYLIGHTS		# OF PANES			N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
									Subtotal				Subtotal

OVERALL ENVELOPE METHOD (Part 4of 6) ENV-2

PROJECT NAME	DATE

OVERALL HEAT GAIN FROM RADIATION OPAQUE SURFACES (i.e. Roofs)

	A	B	C	D	E	F	G	H	I	J	K
		PROPOSED						STANDARD			
	ASSEMBLY NAME (e.g. Roof-1)	AREA	SOLAR FACTOR	WEIGHT FACTOR	U-FACTOR	Absorp α	HEAT GAIN (B×CxD×ExF)	AREA* (Adjusted)	U-FACTOR	Absorp α	HEAT GAIN (C×DxH×IxJ)

						Subtotal				Subtotal

OVERALL ENVELOPE METHOD (Part 5 of 6) ENV-2

PROJECT NAME	DATE

OVERALL HEAT GAIN FROM RADIATION

FENESTRATION SURFACES

	A	B	C	D	E	F		G	H	I	J	K	L	M
			PROPOSED								STANDARD			
						OVERHANG								
	WINDOW/SKYLIGHT NAME (e.g Window-1, Sky-1)	WEIGHTING FACTOR	AREA	SOLAR FACTOR	SHGC	H	V	H/V	OHF	HEAT GAIN (BxCx DxExH)	AREA (Adjusted)*	RSHG or SHGC**	SOLAR FACTOR	HEAT GAIN (B×J×K×L)
NORTH														
EAST														
SOUTH														
WEST														
SKYLIGHTS						N/A	N/A	N/A	N/A					
						N/A	N/A	N/A	N/A					
						N/A	N/A	N/A	N/A					
						N/A	N/A	N/A	N/A					
						N/A	N/A	N/A	N/A					

Proposed	
Part 3 Subtotal	
Part 4 Subtotal	
Part 5 Subtotal	
TOTAL	

Standard	
Part 3 Subtotal	
Part 4 Subtotal	
Part 5 Subtotal	
TOTAL	

* If Window and/or Skylight Area Adjustment is required, use adjusted areas from part 6 of 6.

** Only SHGC is used for Skylights

Column **I** must be less than column **M**

OVERALL ENVELOPE METHOD (Part 6 of 6) ENV-2

PROJECT NAME	DATE

WINDOW AREA ADJUSTMENT CALCULATIONS

☐ CHECK IF NOT APPLICABLE (see Part 1 of 6)

A WALL NAME (e.g. Wall-1, Wall-2)	ORIENTATION N	 E	 S	 W	B GROSS AREA	C DOOR AREA	D WINDOW AREA	E WINDOW ADJUSTMENT FACTOR (From Part 1)	F ADJUSTED WINDOW AREA (D×E)	G ADJUSTED WALL AREA B-(F+C)
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
TOTALS:										

SKYLIGHT AREA ADJUSTMENT CALCULATIONS

☐ CHECK IF NOT APPLICABLE (see Part 1 of 6)

A ROOF NAME (e.g. Roof-1, Roof-2)	B GROSS AREA	C SKYLIGHT AREA	D SKYLIGHT ADJUSTMENT FACTOR (From Part 1)	E ADJUSTED SKYLIGHT AREA (C×D)	F ADJUSTED ROOF AREA (B – E)
TOTALS:					

PROPOSED WOOD FRAME ASSEMBLY ENV-3

PROJECT NAME	DATE

COMPONENT DESCRIPTION

OUTSIDE INSIDE

SKETCH OF ASSEMBLY

ASSEMBLY NAME

ASSEMBLY TYPE (Check one) Floor / Wall / Ceiling/Roof

FRAMING MATERIAL

FRAMING SIZE Fr %: ______________

FRAMING PERCENTAGE
15% (16” o. c. Wall
12% (24” o. c. Wall)
10% (16” o. c. Floor/Ceil.)
7% (24” o. c. Floor/Ceil.)

CONSTRUCTION COMPONENTS

	DESCRIPTION	R-FACTOR: CAVITY R-FACTOR (Rc)	R-FACTOR: WOOD FRAME R-FACTOR	HEAT CAPACITY (optional): A WALL WEIGHT lbs/sf	HEAT CAPACITY (optional): B SPECIFIC HEAT (Btu/F°•lbs)	HEAT CAPACITY (optional): HC (A×B) (Btu/F°•sf)
1						
2						
3						
4						
5						
6						
7						
	INSIDE SURFACE AIR FILM					
	SUBTOTAL	Rc	Rf		TOTAL HC	

[1/Rc x 1 – (Fr%/100)] + [1/Rf x Fr%/100] = ASSEMBLY U-FACTOR

COMMENTS

PROPOSED METAL FRAME ASSEMBLY — ENV-3

PROJECT NAME | DATE

COMPONENT DESCRIPTION

OUTSIDE

INSIDE

SKETCH OF ASSEMBLY

ASSEMBLY NAME

ASSEMBLY TYPE: Floor / Wall / Ceiling/Roof

FRAMING MATERIAL

FRAMING SIZE

FRAMING SPACING 16” o. c. ☐ 24” o. c. ☐

INSULATION R-VALUE

CONSTRUCTION COMPONENTS

	DESCRIPTION	CAVITY R-VALUE (Rc)
	OUTSIDE SURFACE AIR FILM	
1		
2		
3		
4		
5		
6		
7		
	INSIDE SURFACE AIR FILM	

METAL FRAMING FACTOR			
Stud Spacing	Stud Depth	Insulation R-Value	Non-Mass Wall
16” o. c.	4”	R-7	0.522
		R-11	0.403
		R-13	0.362
		R-15	0.328
	6”	R-19	0.325
		R-21	0.300
		R-22	0.287
		R-25	0.263
24” o. c.	4”	R-7	0.577
		R-11	0.458
		R-13	0.415
		R-15	0.379
	6”	R-19	0.375
		R-21	0.348
		R-22	0.335
		R-25	0.308

Rt

MFF

R-VALUE

R-VALUE

Rt

1/Rt ASSEMBLY U-FACTOR

COMMENTS

PROPOSED MASONRY WALL ASSEMBLY — ENV-3

PROJECT NAME	DATE

COMPONENT DESCRIPTION

OUTSIDE

INSIDE

SKETCH OF ASSEMBLY

ASSEMBLY NAME

DESCRIPTION OF ASSEMBLY

WALL R-VALUE and HEAT CAPACITY

WALL UNIT THICKNESS		NOMINAL INCHES
MATERIAL TYPE		(LW CMU, MW CMU, NW CMU, CLAY UNIT, CLAY BRICK, CONCRETE.)
CORE TREATMENT		(SOLID, GROUTED, EMPTY, INSULATED, NA)
WALL R-VALUE		Rw (FROM TABLE B-4 or B-5)
WALL HEAT CAPACITY		HC (FROM TABLE B-4 or B-5)

FURRING/INSULATION LAYER (INSIDE and/or OUTSIDE IF ANY)

FURRING FRAMING MATERIAL		(WOOD, METAL, NONE)		
FURRING FRAMING SIZE		NOMINAL INCHES		ACTUAL INCHES
FURRING SPACE INSULATION		TYPE		R-VALUE
EXTERIOR INSULATING AREA		TYPE		R-VALUE

FURRING ASSEMBLY EFFECTIVE R-VALUE		**EXTERIOR INSULATING LAYER R-VALUE**		**INSULATION LAYER R-VALUE**	
	+		=		Rf
(FROM TABLE B-7)		(FROM MANUFACTURER)			

WALL ASSEMBLY R-VALUE and U-FACTOR

INSULATION LAYER R-VALUE		**WALL R-VALUE**		**WALL ASSEMBLY R-VALUE**		**WALL ASSEMBLY U-FACTOR**
	+		=		→	
Rf		**Rw**		**Rt**		**1/Rt**

COMMENTS

Mechanical Forms

CERTIFICATE OF COMPLIANCE (Part 1 of 2) MECH-1

PROJECT NAME		DATE
PROJECT ADDRESS		Building Permit
PRINCIPAL DESIGNER-MECHANICAL	TELEPHONE	Checked by/Date
DOCUMENTATION AUTHOR	TELEPHONE	Enforcement Agency Use

GENERAL INFORMATION

DATE OF PLANS	BUILDING CONDITIONED FLOOR AREA	CLIMATE ZONE

BUILDING TYPE ☐ NONRESIDENTIAL ☐ HIGH RISE RESIDENTIAL ☐ HOTEL/MOTEL GUEST ROOM

PHASE OF CONSTRUCTION ☐ NEW CONSTRUCTION ☐ ADDITION ☐ ALTERATION ☐ UNCONDITIONED (file affidavit)

METHOD OF MECHANICAL COMPLIANCE ☐ PRESCRIPTIVE ☐ PERFORMANCE

PROOF OF ENVELOPE COMPLIANCE ☐ PREVIOUS ENVELOPE PERMIT ☐ ENVELOPE COMPLIANCE ATTACHED

STATEMENT OF COMPLIANCE

This Certificate of Compliance lists the building features and performance specifications need to comply with Title 24, Parts 1 and 6 of the California Code of Regulations. This certificate applies only to building mechanical requirements.

The documentation preparer hereby certifies that the documentation is accurate and complete.

DOCUMENTATION AUTHOR	SIGNATURE	DATE

The Principal Mechanical Designer hereby certifies that the proposed building design represented in this set of construction documents is consistent with the other compliance forms and worksheets, with the specifications, and with any other calculations submitted with this permit application. The proposed building has been designed to meet the mechanical requirements contained in the applicable parts of Sections 110 through 115, 120 through 124, 140 through 142, 144 and 145.
Please check one:

- ☐ I hereby affirm that I am eligible under the provisions of Division 3 of the Business and Professions Code to sign this document as the person responsible for it's preparation; and that I am licensed in the State of California as a civil engineer or mechanical engineer, or I am a licensed architect.
- ☐ I affirm that I am eligible under the exemption to Division 3 of the Business and Professions Code by Section 5537.2 or 6737.3 to sign this document as the person responsible for its preparation; and that I am a licensed contractor performing this work.
- ☐ I affirm that I am eligible under the exemption to Division 3 of the Business and Professions Code to sign this document because it pertains to a structure or type of work described pursuant to Business and Professions Code sections 5537, 5538, and 6737.1.

(These sections of the Business and Professions Code are printed in full in the Nonresidential Manual.)

PRINCIPAL MECHANICAL DESIGNER-NAME	SIGNATURE	DATE	LIC. #

MECHANICAL MANDATORY MEASURES

Indicate location on plans of Note Block for Mandatory Measures ______________________

INSTRUCTIONS TO APPLICANT

For Detailed instructions on the use of this and all Energy Efficiency Standards compliance forms, please refer to the Nonresidential Manual published by the California Energy Commission.
MECH-1: Required on plans for all submittals. Part 2 may be incorporated in schedules on plans.
MECH-2: Required for all submittals, but may be incorporated in schedules on plans.
MECH-3: Required for all submittals unless required ventilation rates and airflows are shown on plans, see 4.3.4.
MECH-4: Required for all prescriptive submittals.
MECH-5: Optional. Performance use only for mechanical distribution summary.

CERTIFICATE OF COMPLIANCE (Part 2 of 2) MECH-1

PROJECT NAME	DATE

SYSTEM FEATURES

SYSTEM NAME	MECHANICAL SYSTEMS						NOTE TO FIELD Bldg. Dept. Use
TIME CONTROL							
SETBACK CONTROL							
ISOLATION ZONES							
HEAT PUMP THERMOSTAT?							
ELECTRIC HEAT?							
FAN CONTROL							
VAV MINIMUM POSITION CONTROL?							
SIMULTANEOUS HEAT/COOL?							
HEAT AND COOL SUPPLY RESET?							
HEAT REJECTION CONTROL							
VENTILATION							
OUTDOOR DAMPER CONTROL?							
ECONOMIZER TYPE							
DESIGN O.A. CFM (MECH-3, COLUMN H)							
HEATING EQUIPMENT TYPE							
HIGH EFFICIENCY? / IF YES ENTER EFF. #							
MAKE AND MODEL NUMBER							
COOLING EQUIPMENT TYPE							
HIGH EFFICIENCY? / IF YES ENTER EFF. #							
MAKE AND MODEL NUMBER							
PIPE INSULATION REQUIRED?							
PIPE/DUCT INSULATION PROTECTED?							
HEATING DUCT LOCATION / R-VALUE							
COOLING DUCT LOCATION / R-VALUE							
VERIFIED SEALED DUCTS IN CEILING/ROOF SPACE / %FAN FLOW							

TABLE OF CODES: Enter code from table below into columns above.

	Y:Yes	N:No
HEAT PUMP THERMOSTAT?		
ELECTRIC HEAT?		
VAV MINIMUM POSITION CONTROL?		
HEAT AND COOL SUPPLY RESET?		
SIMULTANEOUS HEAT/COOL?		
HIGH EFFICIENCY?		
PIPE INSULATION REQUIRED?		
PIPE/DUCT INSULATION PROTECTED?		
SEALED DUCTS IN CEILING/ROOF SPACE?		

TIME CONTROL	SETBACK CTRL.	ISOLATION ZONES	FAN CONTROL
S: Prog. Switch O: Occupancy Sensor M: Manual Timer	B: Both C: Cooling H: Heating	Enter number of Isolation Zones	I: Inlet Vanes P: Variable Pitch V: VFD O: Other C: Curve

VENTILATION	OUTDOOR DAMPER	ECONOMIZER	O.A. CFM
B: Air Balance C: Outside Air Cert. M: Outside Air Measure D: Demand Control N: Natural	A: Auto G: Gravity	A: Air W: Water N: Not Required EC: Economizer Control See Section 144(e)3	Enter Design Outdoor Air CFM. Note: This shall be no less than Column H on MECH-3.

MECHANICAL EQUIPMENT SUMMARY (Part 1 of 2) MECH-2

PROJECT NAME	DATE

CHILLER AND TOWER SUMMARY

					PUMPS					
Equipment Name	Equipment Type	Qty.	Effi-ciency	Tons	Total Qty	GPM	BHP	Motor Eff.	Drive Eff.	Pump Control

DHW / BOILER SUMMARY

								TANK INSUL.
System Name	System Type	Distribution Type	Qty.	Rated Input	Vol. (Gals.)	Energy Factor or Recovery Efficiency	Standby Loss or Pilot	Ext. R-Val

CENTRAL SYSTEM RATINGS

			HEATING			COOLING			
System Name	System Type	Qty.	Output	Aux. KW	Effi-ciency	Output	Sensible	Effi-ciency	Economizer Type

CENTRAL FAN SUMMARY

			SUPPLY FAN				RETURN FAN			
System Name	Fan Type	Motor Location	CFM	BHP	Motor Eff.	Drive Eff.	CFM	BHP	Motor Eff.	Drive Eff.

MECHANICAL EQUIPMENT SUMMARY (Part 2 of 2) MECH-2

PROJECT NAME	DATE

VAV SUMMARY

	VAV					FAN					BASEBOARD	
Zone Name	System Type	Qty.	Min. CFM Ratio	Reheat? Type	Reheat? ΔT	Flow Ratio	CFM	BHP	Motor Eff.	Drive Eff.	Type	Output

EXHAUST FAN SUMMARY

EXHAUST FAN						EXHAUST FAN					
Room Name	Qty.	CFM	BHP	Motor Eff.	Drive Eff.	Room Name	Qty.	CFM	BHP	Motor Eff.	Drive Eff.

MECHANICAL VENTILATION MECH-3

PROJECT NAME	DATE

MECHANICAL VENTILATION

A	B	C	D	E	F	G	H	I	J	K
	AREA BASIS			OCCUPANCY BASIS			REQ'D.	DESIGN		
ZONE/ SYSTEM	COND AREA (SF)	CFM PER SF	MIN. CFM (B X C)	NO. OF PEOPLE	CFM PER PERSON	MIN. CFM (E X F)	O.A. (MAX. OF D OR G)	OUTDOOR AIR CFM	VAV MIN. CFM	TRANSFER AIR CFM
	Totals (For MECH-4)									

C Minimum ventilation rate per Section § 121, Table 1-F.

E Based on expected number of occupants or at least 50% of Chapter 10 1997 UBC occupant density

I Must be greater than or equal to H, or use Transfer Air. Design outdoor air includes ventilation from supply air system & exhaust fans, which operate at design conditions.

K Must be greater than or equal to (H - I), and, for VAV, greater than or equal to (H - J).

MECHANICAL SIZING AND FAN POWER — MECH-4

PROJECT NAME	DATE
SYSTEM NAME	FLOOR AREA

NOTE: Provide one copy of this form for each mechanical system when using the Prescriptive Approach.

SIZING and EQUIPMENT SELECTION

1. DESIGN CONDITIONS:

		COOLING	HEATING
- OUTDOOR, DRY BULB TEMPERATURE	(APPENDIX C)		
- OUTDOOR, WET BULB TEMPERATURE	(APPENDIX C)		
- INDOOR, DRY BULB TEMPERATURE	(1993 ASHRAE handbook, See Chap. 8, Fig. 5)		

2. SIZING

			COOLING	HEATING
- DESIGN OUTDOOR AIR				
- ENVELOPE LOAD				
- LIGHTING				
- PEOPLE				
- MISCELLANEOUS EQUIPMENT				
- OTHER		(Describe)		
- OTHER		(Describe)		
- OTHER		(Describe)		
		TOTALS		

	COOLING	HEATING
OTHER LOADS/SAFETY FACTOR (enter 1.21 for cooling and 1.43 heating)		
MAXIMUM ADJUSTED LOAD (TOTALS FROM ABOVE X OTHER LOAD/SAFETY FACTOR)		

3. SELECTION:

	COOLING	HEATING
INSTALLED EQUIPMENT CAPACITY	Kbtu / Hr	Kbtu / Hr

IF INSTALLED CAPACITY EXCEEDS MAXIMUM ADJUSTED LOAD, EXPLAIN ______________________

FAN POWER CONSUMPTION

A	B	C	D	E	F	G
FAN DESCRIPTION	**DESIGN BRAKE HP**	**EFFICIENCY** MOTOR	DRIVE	**NUMBER OF FANS**	**PEAK WATTS** B x E x 746 / (C x D)	**CFM** (Supply Fans)
				TOTALS		

NOTE: Include only fan systems exceeding 25 HP (see § 144). Total Fan System Power Demand may not exceed 0.8 Watts/CFM for constant volume systems or 1.25 Watts/CFM for VAV systems.

TOTAL FAN SYSTEM POWER DEMAND WATTS / CFM ______ Col. F / Col. G

MECHANICAL DISTRIBUTION SUMMARY **PERFORMANCE USE ONLY** MECH-5

PROJECT NAME	DATE
ADDRESS	PERMIT NUMBER

VERIFIED DUCT TIGHTNESS BY INSTALLER

☐ DUCT LEAKAGE REDUCTION **Pressurization Test Results (Aerosol or Manual Sealing) CFM @ 25 PA**

	Measured Values
Test Leakage (CFM)	

Fan Flow

If Fan Flow is Calculated as 400 cfm/ton x number of tons, or as 21.7 x Heating Capacity in Thousands of Btu/hr, enter calculated value here	
If Fan Flow is Measured, enter measured value here	
Leakage Fraction = Test Leakage / (Calculated or Measured Fan Flow)	
Check Box for Pass or Fail (Pass = 6% or less of Leakage Fraction)	☐ Pass ☐ Fail

Tests Performed	Signature	Date	Installing Subcontractor (Co. Name) **OR** General Contractor (Co. Name)

HERS RATER COMPLIANCE STATEMENT

☐ BUILDING TESTED **Pressurization Test Results (Aerosol or Manual Sealing) CFM @ 25 PA**

As the HERS rater providing diagnostic testing and field verification, I certify that the building identified on this form complies with the diagnostic tested compliance requirements as checked on this form.

Supply Duct R-value _______ (R-value 4.2 or greater)
Return Duct R-value _______ (R-value 4.2 or greater)

- ☐ Distribution system is fully ducted (i.e., does not use building cavities as plenums or platform returns in lieu of ducts)
- ☐ Where cloth backed, rubber adhesive duct tape is installed, mastic and drawbands are used in combination with cloth backed, rubber adhesive duct tape to seal leaks at duct connections.
- ☐ Minimum Requirements for Duct Leakage Reduction Compliance Credit

	Measured Values
Test Leakage (CFM)	

Fan Flow

If Fan Flow is Calculated as 400 cfm/ton x number of tons, or as 21.7 x Heating Capacity in Thousands of Btu/hr, enter calculated value here	
If Fan Flow is Measured, enter measured value here	
Leakage Fraction = Test Leakage / (Calculated or Measured Fan Flow)	
Check Box for Pass or Fail (Pass = 6% or less of Leakage Fraction)	☐ Pass ☐ Fail

Tests Performed	Signature	Date	HERS Rater (Name)

COPY TO: Building Department, HERS Provider (if applicable), and Building Owner at Occupancy

Lighting Forms

CERTIFICATE OF COMPLIANCE	(Part 1 of 3)	LTG-1

PROJECT NAME		DATE
PROJECT ADDRESS		
PRINCIPAL DESIGNER-LIGHTING	TELEPHONE	Building Permit
DOCUMENTATION AUTHOR	TELEPHONE	Checked by/Date Enforcement Agency Use

GENERAL INFORMATION

DATE OF PLANS	BUILDING CONDITIONED FLOOR AREA	CLIMATE ZONE

BUILDING TYPE ☐ NONRESIDENTIAL ☐ HIGH RISE RESIDENTIAL ☐ HOTEL/MOTEL GUEST ROOM

PHASE OF CONSTRUCTION ☐ NEW CONSTRUCTION ☐ ADDITION ☐ ALTERATION ☐ UNCONDITIONED (file affidavit)

☐ COMPLETE BLDG. ☐ AREA CATEGORY ☐TAILORED ☐ PERFORMANCE

STATEMENT OF COMPLIANCE

This Certificate of Compliance lists the building features and performance specifications need to comply with Title 24, Parts 1 and 6 of the California Code of Regulations. This certificate applies only to building lighting requirements.

The documentation preparer hereby certifies that the documentation is accurate and complete.

DOCUMENTATION AUTHOR	SIGNATURE	DATE

The Principal Lighting Designer hereby certifies that the proposed building design represented in this set of construction documents is consistent with the other compliance forms and worksheets, with the specifications, and with any other calculations submitted with this permit application. The proposed building has been designed to meet the lighting requirements contained in the applicable parts of Sections 110, 119,130 through 132, 146, and 149 of Title 24, Part 6.
Please check one:

☐ I hereby affirm that I am eligible under the provisions of Division 3 of the Business and Professions Code to sign this document as the person responsible for its preparation; and that I am licensed in the State of California as a civil engineer or electrical engineer, or I am a licensed architect.

☐ I affirm that I am eligible under the provisions of Division 3 of the Business and Professions Code by section 5537.2 or 6737.3 to sign this document as the person responsible for its preparation; and that I am a licensed contractor performing this work.

☐ I affirm that I am eligible under Division 3 of the Business and Professions Code to sign this document because it pertains to a structure or type of work described as exempt pursuant to Business and Professions Code Sections 5537,5538 and 6737.1.

(These sections of the Business and Professions Code are printed in full in the Nonresidential Manual.)

PRINCIPAL LIGHTING DESIGNERS NAME	SIGNATURE	DATE	LIC. #

LIGHTING MANDATORY MEASURES

Indicate location on plans of Note Block for Mandatory Measure ______________________

INSTRUCTIONS TO APPLICANT

For detailed instructions on the use of this and all Energy Efficiency Standards compliance forms, please refer to the Nonresidential Manual published by the California Energy Commission.
LTG-1: Required on plans for all submittals. Part 2 and 3 may be incorporated in schedules on plans.
LTG-2: Required for all submittals.
LTG-3: Optional. Uses only if lighting control credits are taken.
LTG-4: Optional. Part 2 and 3 and LTG-5 are optional if Tailored Method if used.

CERTIFICATE OF COMPLIANCE (Part 2 of 3) LTG-1

PROJECT NAME	DATE

INSTALLED LIGHTING SCHEDULE

		LAMPS			BALLAST		LUMINAIRE		TOTAL WATTS
Name	LUMINAIRE DESCRIPTION	Type DESCRIPTION	No. of Lamps	Watts Per Lamp	Type DESCRIPTION	No. of Ballast	No. of Lumin.	Watts/ Lumin.	

Lighting Schedule on Plans Shows Exterior Lighting Meets

- ☐ Efficacy and Control Requirement of § 130I
- ☐ Control Requirements of § 131(f)

SUBTOTAL FROM THIS PAGE	
PLUS SUBTOTAL FROM CONTINUATION PAGE	
PORTABLE LIGHTING (From LTG-1 Part 3 of 3)	
LESS CONTROL CREDIT WATTS (From LTG-3)	
ADJUSTED ACTUAL WATTS	

MANDATORY AUTOMATIC CONTROLS

CONTROL LOCATION (Room #)	CONTROL IDENTIFICATION	CONTROL TYPE (Auto Time Switch, Exterior, etc.)	SPACE CONTROLLED	NOTE TO FIELD

CONTROLS FOR CREDIT

CONTROL LOCATION (Room # or Dwg. #)	CONTROL IDENTIFICATION	CONTROL TYPE (Occupant, Daylight, Dimming, etc.)	LUMINAIRES CONTROLLED		NOTE TO FIELD
			TYPE	# OF LUMINAIRES	

NOTES TO FIELD – For Building Department Use Only

PORTABLE LIGHTING WORKSHEET (Part 3 of 3) LTG-1

PROJECT NAME	DATE

TABLE 1A – PORTABLE LIGHTING NOT SHOWN ON PLANS FOR OFFICE AREA > 250 SQUARE FEET

A	B	C	D
ROOM # OR ZONE ID	DEFAULT (WATTS)	AREA (SF)	TOTAL WATTS (B X C)
	0.2		
	0.2		
	0.2		
	0.2		
	0.2		
	0.2		
	TOTAL		

TABLE 1B – PORTABLE LIGHTING SHOWN ON PLANS FOR OFFICE AREA > 250 SQUARE FEET

A	B	C	D	E	F	G
ROOM # OR ZONE ID	PORTABLE LIGHTING DESCRIPTION (S) PER TASK AREA	LUMINAIRE (S) WATTS PER TASK AREA	TASK AREA (SF)	NUMBER OF TASK AREAS	TOTAL AREA (SF) (D X E)	TOTAL WATTS (C X E)
				TOTAL		

TABLE 1C – PLANS SHOW PORTABLE LIGHTING IS NOT REQUIRED FOR OFFICE AREAS > 250 SQUARE FEET

ROOM # OR ZONE ID	TOTAL AREA (SF)	
		Designer needs to provide detailed documentation that the lighting level provided by the overhead lighting meets the needs of the space. The details include luminaire types, CU, and mounting locations relative to work areas.
TOTAL		

BUILDING SUMMARY – PORTABLE LIGHTING

BUILDING SUMMARY	TOTAL AREA (SF) (FROM TABLES 1A+1B+1C)	TOTAL WATTS (FROM TABLES 1A+1B)
BUILDING TOTAL		

Enter on LTG-1 and 2: Portable Lighting

LIGHTING COMPLIANCE SUMMARY LTG-2

PROJECT NAME	DATE

ACTUAL LIGHTING POWER

LUMINAIRE NAME	Type DESCRIPTION	NUMBER OF LUMINAIRES	WATTS PER LUMINAIRE (Including Ballast)	CEC DEFAULT? Y	N	TOTAL WATTS
				☐	☐	
				☐	☐	
				☐	☐	
				☐	☐	
				☐	☐	
				☐	☐	
				☐	☐	
				☐	☐	
				☐	☐	

SUBTOTAL FROM THIS PAGE	
PLUS SUBTOTAL FROM CONTINUATION PAGE	
PORTABLE LIGHTING (From LTG-1 Part 3 of 3)	
LESS CONTROL CREDIT WATTS (From LTG-3)	
ADJUSTED ACTUAL WATTS	

ALLOWED LIGHTING POWER (Choose One Method)

COMPLETE BUILDING METHOD

BUILDING CATEGORY (From § 146(b) Table 1-M)	**WATTS PER SF**	**COMPLETE BLDG. AREA**	**ALLOWED WATTS**

AREA CATEGORY METHOD

AREA CATEGORY (From § 146(b) Table 1-N)	**WATTS PER SF**	**AREA (SF)**	**ALLOWED WATTS**
	TOTALS	AREA	WATTS

TAILORED METHOD

TOTAL ALLOWED WATTS (From LTG-4)	

LIGHTING CONTROLS CREDIT WORKSHEET LTG-3

PROJECT NAME	DATE

WORKSHEET

A	B	C	D	E	F	G	H	I
			ROOM	DAYLIGHTING		CONTROL	LIGHTING	CONTROL
ROOM # ZONE ID	LIGHTING CONTROL DESCRIPTION	PLANS REF.	AREA (SF)	ROOM RATIO*	GLAZING VLT	LIGHTING (Watts)	ADJUSTMENT FACTOR	CREDIT WATTS (G X H)

*For windows, use the Window Wall Ratio for the room. For skylights, use the Skylight-to Roof ratio for the room.

PAGE TOTAL →

BUILDING TOTAL →

Enter on LTG-1 and 2: Plus Subtotal From Continuation Page

TAILORED LPD SUMMARY and WORKSHEET (Part 1 of 3) LTG-4

PROJECT NAME	DATE

TAILORED METHOD

1. Watts for Illuminance Categories A-D (from column G below) → ______ WATTS

2.Watts for Illuminance Categories E-I (from LTG-4 Part 2) → ______ WATTS

3. Watts for Display Lighting (from LTG-4 Parts 2 & 3)

______ + ______ + ______ = ______ WATTS

Public Area Display | Sales Feature Floor Display | Sales Feature Wall Display

4. Total Allowed Watts (lines 1+2+3) → ______ WATTS

TAILORED LPD – Illuminance Categories A, B, C and D and Gross Sales Floor Area

A ROOM NUMBER	B TASK/ACTIVITY	C ILLUMINANCE CATEGORY	D ROOM CAVITY RATIO	E FLOOR AREA	F ALLOWED LPD	G ALLOWED WATTS (E X F)

PAGE TOTAL →		
BUILDING TOTAL →		
	SF	WATTS

TAILORED LPD SUMMARY and WORKSHEET (Part 2 of 3) LTG-4

PROJECT NAME	DATE

TAILORED LPD – Illuminance Categories E, F, G, H, I and Gross Sales Wall Area

A	B	C	D	E	F	G	H	I	J	K	L
				ALLOTTED WATTS			**DESIGN WATTS**				
TASK / ACTIVITY	Illum. Cat.	RCR (If E)	Notes*	TASK AREA (sf)	ALLOWED LPD	ALLOTTED WATTS (E X F)	LUMIN. NAME	QTY Of LUMIN.	WATTS/ LUMIN.	DESIGN WATTS (I X J)	**ALLOWED WATTS** (Min. G or K)

PAGE TOTAL →

BUILDING TOTAL →

* Enter Mounting Height or Throw Distance or Both if applicable.

TAILORED LPD – Public Area Displays

A	B	C	D	E	F	G	H	I	J	K
			ALLOTTED WATTS			**DESIGN WATTS**				
TASK / ACTIVITY	Throw Dist.	Mtg. Hgt.	TASK AREA (sf)	ALLOWED LPD	ALLOTTED WATTS (D X E)	LUMIN. NAME	QTY. Of LUMIN.	WATTS/ LUMIN.	DESIGN WATTS (H X I)	**ALLOWED WATTS** (Min. F or J)

TOTAL AREA PUBLIC DISPLAYS ____ SF

TOTAL ____ WATTS

PLANE OF PUBLIC DISPLAY AREA ____ X 0.1 = ____ MAXIMUM AREA PUBLIC DISPLAYS (SF)

TAILORED LPD SUMMARY and WORKSHEET (Part 3 of 3) LTG-4

PROJECT NAME	DATE

TAILORED LPD – Sales Feature Floor Displays

A	B	C	D	E	F	G	H	I	J	K
			ALLOTTED WATTS			**DESIGN WATTS**				
TASK / ACTIVITY	THROW DISTANCE	MOUNT. HEIGHT	TASK AREA (sf)	CAT. G ALLOWED LPD	ALLOTTED WATTS (D X E)	LUMIN. NAME	QTY. Of LUMIN.	WATTS/ LUMIN.	DESIGN WATTS (H X I)	**ALLOWED WATTS** (Min. F or J)

TOTAL AREA FLOOR DISPLAYS [ ] SF TOTAL WATTS [ ]

GROSS SALES FLOOR AREA [ ] X 0.1 = [ ] MAXIMUM AREA FLOOR DISPLAYS (SF)

TAILORED LPD – Sales Feature Wall Displays

A	B	C	D	E	F	G	H	I	J
		ALLOTTED WATTS			DESIGN WATTS				
TASK / ACTIVITY	THROW DISTANCE	TASK AREA (sf)	Cat. G ALLOWED LPD	ALLOTTED WATTS (C X D)	LUMIN. NAME	QTY. Of LUMIN.	WATTS\ LUMIN.	DESIGN WATTS (G XH)	**ALLOWED WATTS** (Min. E or I)

TOTAL AREA WALL DISPLAYS [ ] SF TOTAL WATTS [ ]

GROSS SALES WALL AREA [ ] X 0.1 = [ ] MAXIMUM AREA WALL DISPLAYS (SF)

ROOM CAVITY RATIO WORKSHEET (RCR $\geq$ 3.5) LTG-5

PROJECT NAME		FOR ENFORCEMENT AGENCY USE ONLY	
DOCUMENTATION AUTHOR	DATE	PLAN CHECKED BY	DATE

RECTANGULAR SPACES

A	B	C	D	E	F
Room Number	Task/Activity Description	Room Length (L)	Room Width (W)	Room Height (H)	Room Cavity Ratio 5 x H x (L+W) / (L x W)

NON-RECTANGULAR SPACES

A	B	C	D	E	F
Room Number	Task/Activity Description	Room Area (A)	Room Perimeter (P)	Room Height (H)	Room Cavity Ratio (2.5 x H x P) / A

DEFAULT U-FACTOR AND SHGC LABEL CERTIFICATE FORM

ALTERNATIVE U-FACTOR AND SHGC LABEL CERTIFICATE FORM

SAMPLES FORMS

DEFAULT U-FACTOR AND SHGC LABEL CERTIFICATE FORM

PROJECT INFORMATION	
PROJECT NAME:	DATE:
PROJECT ADDRESS:	

CEC DEFAULT U-FACTOR AND SHGC LABEL CERTIFICATE (Use only for Site-Assembled Fenestration Product Lines) Method 1 in this Default Certificate may be used for site-assembled vertical glazing installed in all non-residential buildings.	U-factors and SHGC are derived from the California Energy Commission Fenestration Default U-factors and SHGC Default Table based on data reported below. **U-factor = ___** **SHGC = ___** This Fenestration Product Line meets the air infiltration requirements of Section 116(a) 1, 2001 California Energy Efficiency Standards for Residential and Nonresidential Buildings.

PRODUCT LINE INFORMATION (Complete a separate Default Label Certificate for each fenestration product line in the project)			
Total Number of units for this product line:	______	Total square footage of this product line:	______
Elevation drawing page:	______	Fenestration (window & door) schedule page:	______
Location(s) on building: (enter appropriate orientation(s))	______	Total Fenestration Area (ft^2) on project:	______

❑ **Method 1 - DEFAULT FENESTRATION U-FACTOR AND SHGC FROM TABLES 3-10 AND 3-12 OF THE NONRESIDENTIAL MANUAL FOR COMPLIANCE WITH THE 2001 ENERGY EFFICIENCY STANDARDS**

Frame Type	❑ Metal	❑ Metal Thermal Break (or Structural Glazing)				❑ Nonmetal
U-factor Table 3-10 Product Type	❑ Operable	❑ Fixed	❑ Greenhouse, Garden Window		❑ Door	❑ Skylight
Glazing Type	❑ Single Pane	❑ Double Pane	**Default U-factor** =	_____	(If no adjustment, insert value in above gray box next to U-factor)	
SHGC Table 3-12 Product Type	❑ Operable	❑ Fixed				
SHGC Table 3-12 Glazing Tint	❑ Clear	❑ Tint	**Default SHGC =**	______	(Insert default value in above gray box next to SHGC)	

U-Factor Adjustment (See Table 3-10, Footnote 2)

❑ Subtract 0.05 for spacers of 7/16 inch or wider
❑ Subtract 0.05 for products certified by the manufacturer as low-E glazing.
❑ Add 0.05 for products with dividers between panes if spacer is less than 7/16 inch wide.
❑ Add 0.05 for products with true divided lite (dividers through the panes).

U-Factor Adjustment = ____________________	(If applicable insert adjustment result in above gray box next to U-factor)

PERSON TAKING RESPONSIBILITY FOR FENESTRATION COMPLIANCE CONTACT PERSON:		
Contact Person:		
Company name and address:		
Phone:	Fax:	Signature:

ALTERNATIVE DEFAULT U-FACTOR and SHGC LABEL CERTIFICATE

PROJECT INFORMATION	
PROJECT NAME:	DATE:
PROJECT ADDRESS:	

CEC ALTERNATIVE DEFAULT U-FACTOR AND SHGC LABEL CERTIFICATE (Use only for Site-Assembled Fenestration Product Lines) Method 2 Alternative Default Certificate shall not be used for site-assembled vertical glazing installed in buildings with 100,000 square feet or more of conditioned floor area and 10,000 square feet or more of vertical glazing.	U-factors and SHGC are derived from the California Energy Commission Fenestration Alternative Default U-factors and SHGC Equations based on data reported below. **U-factor = ____** **SHGC = ____** This Fenestration Product Line meets the air infiltration requirements of Section 116(a) 1, 2001 California Energy Efficiency Standards for Residential and Nonresidential Buildings.

PRODUCT LINE INFORMATION (Complete a separate Default Label Certificate for each fenestration product line in the project)			
Total Number of units for this product line:	______	Total square footage of this product line:	______
Elevation drawing page:	______	Fenestration (window & door) schedule page:	______
Location(s) on building: S, N, E, W (Enter appropriate orientation(s))	______	Total Fenestration Area (ft^2) on project:	______

❑ Method 2 - DEFAULT FENESTRATION U-FACTOR AND SHGC FROM APPENDIX B, TABLE B-14 AND MANUFACTURER'S DOCUMENTATION

Product Type	❑ Glazed Wall Systems	❑ Skylight with Curb	❑ Skylight without Curb			
Frame Type	❑ Aluminum	❑ Aluminum Metal Thermal Break	❑ Wood/Vinyl	❑ Reinforced Vinyl/ Aluminum Clad Wood	❑ Structural Glazing	
Glazing Type, Glazing Thickness	❑ Single ⅛" Glass	❑ Single ⅛" Acrylic/polycarb	❑ Single ¼ " Acrylic/polycarb	❑ Double-Glass	❑ Triple Glazing	❑ Quadruple Glazing
Coating Emissivity	❑ 0.05	❑ 0.10	❑ 0.20	❑ 0.40	❑ 0.60	
Coated Surfaces	❑ 2 or 3	❑ 2, 3, 4, or 5	❑ 2 or 3 and 4 or 5			
Glazing Spacing	❑ 1/4" Airspace	❑ 1/2" Airspace				
Gas Fill between Panes	❑ Air	❑ Argon	❑ Krypton			

CEC ALTERNATIVE DEFAULT FENESTRATION U-FACTOR =	___	From Assembly U-Factors - Appendix B, Table B-14 (Insert value in above gray box next to U-factor)

DEFAULT SOLAR HEAT GAIN COEFFICIENT			
SHGC for Center of Glass	**SHGCc** =	___	From Manufacturer's Documentation (Insert value "**SHGCc** " in equation below)
Calculate SHGC Fenestration Equation from Appendix B, Table B-12 (Site-Assembled)	$\mathbf{SHGC_{fen} = 0.08 + (0.86 \times SHGCc)}$ =	___	(Insert result value in above gray box next to SHGC)

ATTACHED MANUFACTURED DOCUMENTATION

Manufacturer's documentation must be attached showing the Product Type, Frame Type, Glazing Type, and SHGCc information needed to determine the Default U-factor and SHGC from the Applicable Table or equation.

PERSON TAKING RESPONSIBILITY FOR FENESTRATION COMPLIANCE CONTACT PERSON:		
Contact Person:		
Company name and address:		
Phone:	Fax:	Signature:

DEFAULT U-FACTOR AND SHGC LABEL CERTIFICATE FORM SAMPLE

PROJECT INFORMATION **SAMPLE**	
PROJECT NAME: **RIVER CITY OFFICE** SAMPLE	DATE: **August 1, 2001**
PROJECT ADDRESS: **321 North 5th St. Sacramento, CA 95814** **SAMPLE**	

CEC DEFAULT U-FACTOR AND SHGC LABEL CERTIFICATE (Use only for Site-Assembled Fenestration Product Lines) Method 1 in this Default Certificate may be used for site-assembled vertical glazing installed in all non-residential buildings.	U-factors and SHGC are derived from the California Energy Commission Fenestration Default U-factors and SHGC Default Table based on data reported below. **U-factor = 0.71** **SHGC = 0.73** This Fenestration Product Line meets the air infiltration requirements of Section 116(a) 1, 2001 California Energy Efficiency Standards for Residential and Nonresidential Buildings.

PRODUCT LINE INFORMATION (Complete a separate Default Label Certificate for each fenestration product line in the project)			
Total Number of units for this product line:	**2**	Total square footage of this product line:	**480**
Elevation drawing page:	**E-3**	Fenestration (window & door) schedule page:	**E-4, E-6**
Location(s) on building: (enter appropriate orientation(s))	**South, East, West and North**	Total Fenestration Area (ft^2) on project:	**960**

❑ **Method 1 - DEFAULT FENESTRATION U-FACTOR AND SHGC FROM TABLES 3-10 AND 3-12 OF THE NONRESIDENTIAL MANUAL FOR COMPLIANCE WITH THE 2001 ENERGY EFFICIENCY STANDARDS**

Frame Type	✕ Metal	❑ Metal Thermal Break (or Structural Glazing)			❑ Nonmetal
U-factor Table 3-10 Product Type	❑ Operable	✕ Fixed	❑ Greenhouse, Garden Window	❑ Door	❑ Skylight
Glazing Type	❑ Single Pane	✕ Double Pane	**Default U-factor** =	**0.72**	(If no adjustment, insert value in above gray box next to U-factor)
SHGC Table 3-12 Product Type	❑ Operable	✕ Fixed			
SHGC Table 3-12 Glazing Tint	✕ Clear	❑ Tint	**Default SHGC =**	**0.73**	(Insert default value in above gray box next to SHGC)

U-Factor Adjustment (See Table 3-10, Footnote 2)

✕ Subtract 0.05 for spacers of 7/16 inch or wider
✕ Subtract 0.05 for products certified by the manufacturer as low-E glazing.
❑ Add 0.05 for products with dividers between panes if spacer is less than 7/16 inch wide.
❑ Add 0.05 for products with true divided lite (dividers through the panes).

U-Factor Adjustment = 0.72 – 0.05 – 0.05 = **0.71**	(If applicable insert adjustment result in above gray box next to U-factor)

PERSON TAKING RESPONSIBILITY FOR FENESTRATION COMPLIANCE CONTACT PERSON:		
Contact Person: **Joe Glassguy** **SAMPLE**		
Company name and address: **453 Venice Way** **SAMPLE**		
Phone: **916-555-5555**	Fax:	Signature: *Joe Glassguy*

ALTERNATIVE DEFAULT U-FACTOR and SHGC LABEL CERTIFICATE

PROJECT INFORMATION SAMPLE	
PROJECT NAME: **RIVER CITY OFFICE** **SAMPLE**	DATE: **August 1, 2001**
PROJECT ADDRESS: SAMPLE **3212 North 5th St. Sacramento, CA 95814**	

CEC ALTERNATIVE DEFAULT U-FACTOR AND SHGC LABEL CERTIFICATE **(Use only for Site-Assembled Fenestration Product Lines)** Method 2 Alternative Default Certificate shall not be used for site-assembled vertical glazing installed in buildings with 100,000 square feet or more of conditioned floor area and 10,000 square feet or more of vertical glazing.	U-factors and SHGC are derived from the California Energy Commission Fenestration Alternative Default U-factors and SHGC Equations based on data reported below. **U-factor = 0.66** **SHGC = 0.42** This Fenestration Product Line meets the air infiltration requirements of Section 116(a) 1, 2001 California Energy Efficiency Standards for Residential and Nonresidential Buildings.

PRODUCT LINE INFORMATION (Complete a separate Default Label Certificate for each fenestration product line in the project)			
Total Number of units for this product line:	**2**	Total square footage of this product line:	**480**
Elevation drawing page:	**E-3**	Fenestration (window & door) schedule page:	**E-4, E-6**
Location(s) on building: (Enter appropriate orientation(s))	**South, East, West and North**	Total Fenestration Area (ft^2) on project:	**960**

❑ Method 2 - DEFAULT FENESTRATION U-FACTOR AND SHGC FROM APPENDIX B, TABLE B-14 AND MANUFACTURER'S DOCUMENTATION

Product Type	X Glazed Wall Systems	❑ Skylight with Curb	❑ Skylight without Curb			
Frame Type	X Aluminum	❑ Aluminum Metal Thermal Break	❑ Wood/Vinyl	❑ Reinforced Vinyl/ Aluminum Clad Wood	❑ Structural Glazing	
Glazing Type, Glazing Thickness	❑ Single ⅛" Glass	❑ Single ⅛" Acrylic/polycarb	❑ Single ¼ " Acrylic/polycarb	X Double-Glass	❑ Triple Glazing	❑ Quadruple Glazing
Coating Emissivity	❑ 0.05	❑ 0.10	❑ 0.20	X 0.40	❑ 0.60	
Coated Surfaces	X 2 or 3	❑ 2, 3, 4, or 5	❑ 2 or 3 and 4 or 5			
Glazing Spacing	❑ 1/4" Airspace	X 1/2" Airspace				
Gas Fill between Panes	X Air	❑ Argon	❑ Krypton			

CEC ALTERNATIVE DEFAULT FENESTRATION U-FACTOR =	**0.66**	From Assembly U-Factors - Appendix B, Table B-14 (Insert value in above gray box next to U-factor)

DEFAULT SOLAR HEAT GAIN COEFFICIENT			
SHGC for Center of Glass	**SHGCc** =	**0.40**	From Manufacturer's Documentation (Insert value "**SHGCc** " in equation below)
Calculate SHGC Fenestration Equation from Appendix B, Table B-12 (Site-Assembled)	$SHGC_{fen} = 0.08 + (0.86 \times SHGCc) =$	**0.42**	(Insert result value in above gray box next to SHGC)

ATTACHED MANUFACTURED DOCUMENTATION
Manufacturer's documentation must be attached showing the Product Type, Frame Type, Glazing Type, and SHGCc information needed to determine the Default U-factor and SHGC from the Applicable Table or equation.

PERSON TAKING RESPONSIBILITY FOR FENESTRATION COMPLIANCE CONTACT PERSON:		
Contact Person: **Joe Glassguy** **SAMPLE**		
Company name and address: **453 Venice Way** **SAMPLE**		
Phone: **916-555-5555**	Fax:	Signature: *Joe Glassguy*

B. Materials Reference

CHAPTER 24

THERMAL AND WATER VAPOR TRANSMISSION DATA

Building Envelopes 24.1
Calculating Overall Thermal Resistances 24.2
Mechanical and Industrial Systems 24.15
Calculating Heat Flow for Buried Pipelines 24.23

THIS chapter presents thermal and water vapor transmission data based on steady-state or equilibrium conditions. Chapter 3 covers heat transfer under transient or changing temperature conditions. Chapter 22 discusses selection of insulation materials and procedures for determining overall thermal resistances by simplified methods.

BUILDING ENVELOPES

Thermal Transmission Data for Building Components

The steady-state thermal resistances (R-values) of building components (walls, floors, windows, roof systems, etc.) can be calculated from the thermal properties of the materials in the component; or the heat flow through the assembled component can be measured directly with laboratory equipment such as the guarded hot box (ASTM *Standard* C 236) or the calibrated hot box (ASTM *Standard* C 976).

Tables 1 through 6 list thermal values, which may be used to calculate thermal resistances of building walls, floors, and ceilings. The values shown in these tables were developed under ideal conditions. In practice, overall thermal performance can be reduced significantly by such factors as improper installation and shrinkage, settling, or compression of the insulation (Tye and Desjarlais 1983; Tye 1985, 1986).

Most values in these tables were obtained by accepted ASTM test methods described in ASTM *Standards* C 177 and C 518 for materials and ASTM *Standards* C 236 and C 976 for building envelope components. Because commercially available materials vary, not all values apply to specific products.

The most accurate method of determining the overall thermal resistance for a combination of building materials assembled as a building envelope component is to test a representative sample by a hot box method. However, all combinations may not be conveniently or economically tested in this manner. For many simple constructions, calculated R-values agree reasonably well with values determined by hot box measurement.

The performance of materials fabricated in the field is especially subject to the quality of workmanship during construction and installation. Good workmanship becomes increasingly important as the insulation requirement becomes greater. Therefore, some engineers include additional insulation or other safety factors based on experience in their design.

Figure 1 shows how convection affects surface conductance of several materials. Other tests on smooth surfaces show that the average value of the convection part of the surface conductance decreases as the length of the surface increases.

Vapor retarders, which are discussed in Chapters 22 and 23, require special attention. Moisture from condensation or other sources may reduce the thermal resistance of insulation, but the effect of moisture must be determined for each material. For example, some materials with large air spaces are not affected significantly if the moisture content is less than 10% by weight, while the effect of moisture on other materials is approximately linear.

Ideal conditions of components and installations are assumed in calculating overall R-values (i.e., insulating materials are of uniform nominal thickness and thermal resistance, air spaces are of uniform thickness and surface temperature, moisture effects are not involved, and installation details are in accordance with design). The National Institute of Standards and Technology Building Materials and Structures Report BMS 151 shows that measured values differ from calculated values for certain insulated constructions. For this reason, some engineers decrease the calculated R-values a moderate amount to account for departures of constructions from requirements and practices.

Tables 3 and 2 give values for well-sealed systems constructed with care. Field applications can differ substantially from laboratory test conditions. Air gaps in these insulation systems can seriously degrade thermal performance as a result of air movement due to both natural and forced convection. Sabine et al. (1975) found that the tabular values are not necessarily additive for multiple-layer, low-emittance air spaces, and tests on actual constructions should be conducted to accurately determine thermal resistance values.

Values for foil insulation products supplied by manufacturers must also be used with caution because they apply only to systems that are identical to the configuration in which the product was tested. In addition, surface oxidation, dust accumulation, condensation, and other factors that change the condition of the low-emittance surface can reduce the thermal effectiveness of

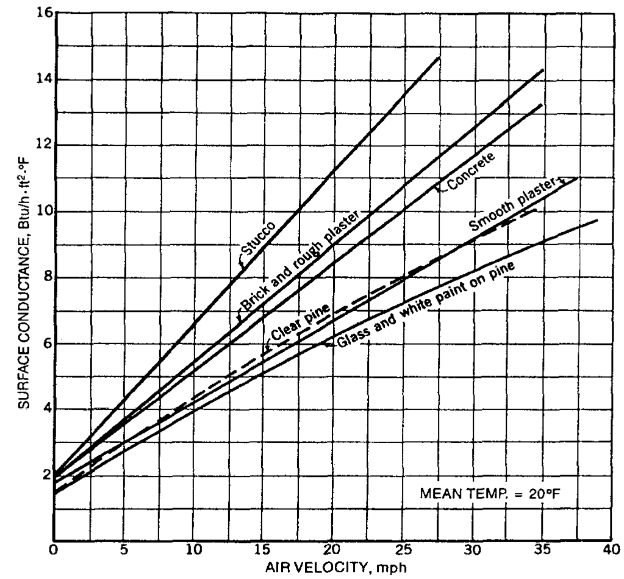


Fig. 1 Surface Conductance for Different Surfaces as Affected by Air Movement

The preparation of this chapter is assigned to TC 4.4, Thermal Insulation and Moisture Retarders.

Table 1 Surface Conductances and Resistances for Air

Position of Surface	Direction of Heat Flow	Surface Emittance, ε: Non-reflective ε = 0.90 h_i	R	Reflective ε = 0.20 h_i	R	Reflective ε = 0.05 h_i	R
STILL AIR							
Horizontal	Upward	1.63	0.61	0.91	1.10	0.76	1.32
Sloping—45°	Upward	1.60	0.62	0.88	1.14	0.73	1.37
Vertical	Horizontal	1.46	0.68	0.74	1.35	0.59	1.70
Sloping—45°	Downward	1.32	0.76	0.60	1.67	0.45	2.22
Horizontal	Downward	1.08	0.92	0.37	2.70	0.22	4.55
MOVING AIR (Any position)		h_o	R				
15-mph Wind (for winter)	Any	6.00	0.17	—	—	—	—
7.5-mph Wind (for summer)	Any	4.00	0.25	—	—	—	—

Notes:
1. Surface conductance h_i and h_o measured in Btu/h·ft²·°F; resistance R in °F·ft²·h/Btu.
2. No surface has both an air space resistance value and a surface resistance value.
3. For ventilated attics or spaces above ceilings under summer conditions (heat flow down), see Table 5.
4. Conductances are for surfaces of the stated emittance facing virtual blackbody surroundings at the same temperature as the ambient air. Values are based on a surface-air temperature difference of 10°F and for surface temperatures of 70°F.
5. See Chapter 3 for more detailed information, especially Tables 5 and 6, and see Figure 1 for additional data.
6. Condensate can have a significant impact on surface emittance (see Table 2).

these insulation systems (Hooper and Moroz 1952). Deterioration results from contact with several types of solutions, either acidic or basic (e.g., wet cement mortar or the preservatives found in decay-resistant lumber). Polluted environments may cause rapid and severe material degradation. However, site inspections show a predominance of well-preserved installations and only a small number of cases in which rapid and severe deterioration has occurred. An extensive review of the reflective building insulation system performance literature is provided by Goss and Miller (1989).

CALCULATING OVERALL THERMAL RESISTANCES

Relatively small, highly conductive elements in an insulating layer called thermal bridges can substantially reduce the average thermal resistance of a component. Examples include wood and metal studs in frame walls, concrete webs in concrete masonry walls, and metal ties or other elements in insulated wall panels. The following examples illustrate the calculation of R-values and U-factors for components containing thermal bridges.

These conditions are assumed in calculating the design R-values:

- Equilibrium or steady-state heat transfer, disregarding effects of thermal storage
- Surrounding surfaces at ambient air temperature
- Exterior wind velocity of 15 mph for winter (surface with R = 0.17°F·ft²·h/Btu) and 7.5 mph for summer (surface with R = 0.25°F·ft²·h/Btu)
- Surface emittance of ordinary building materials is 0.90

Wood Frame Walls

The average overall R-values and U-factors of wood frame walls can be calculated by assuming either parallel heat flow paths through areas with different thermal resistances or by assuming isothermal planes. Equations (1) through (5) from Chapter 22 are used.

Table 2 Emittance Values of Various Surfaces and Effective Emittances of Air Spaces[a]

Surface	Average Emittance ε	Effective Emittance ε_{eff} of Air Space: One Surface Emittance ε; Other, 0.9	Both Surfaces Emittance ε
Aluminum foil, bright	0.05	0.05	0.03
Aluminum foil, with condensate just visible (> 0.7 gr/ft²)	0.30[b]	0.29	—
Aluminum foil, with condensate clearly visible (> 2.9 gr/ft²)	0.70[b]	0.65	—
Aluminum sheet	0.12	0.12	0.06
Aluminum coated paper, polished	0.20	0.20	0.11
Steel, galvanized, bright	0.25	0.24	0.15
Aluminum paint	0.50	0.47	0.35
Building materials: wood, paper, masonry, nonmetallic paints	0.90	0.82	0.82
Regular glass	0.84	0.77	0.72

[a]These values apply in the 4 to 40 μm range of the electromagnetic spectrum.
[b]Values are based on data presented by Bassett and Trethowen (1984).

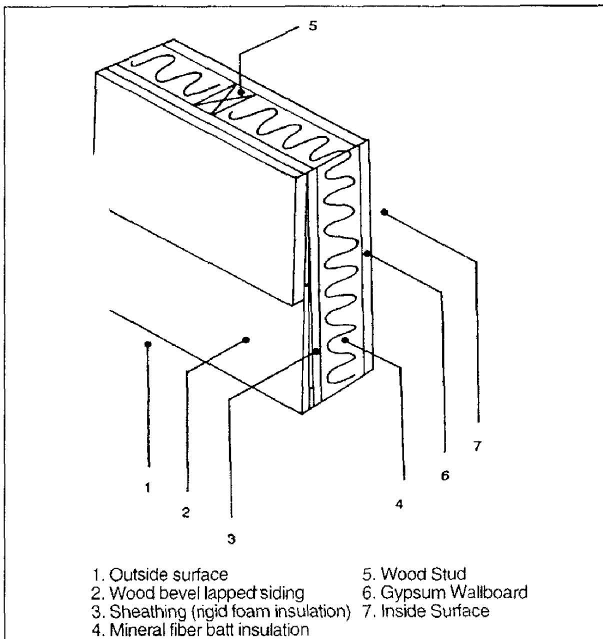


Fig. 2 Insulated Wood Frame Wall (Example 1)

The framing factor or fraction of the building component that is framing depends on the specific type of construction, and it may vary based on local construction practices—even for the same type of construction. For stud walls 16 in. on center (OC), the fraction of insulated cavity may be as low as 0.75, where the fraction of studs, plates, and sills is 0.21 and the fraction of headers is 0.04. For studs 24 in. OC, the respective values are 0.78, 0.18, and 0.04. These fractions contain an allowance for multiple studs, plates, sills, extra framing around windows, headers, and band joists. These assumed framing fractions are used in the following example, to illustrate the importance of including the effect of framing in determining the overall thermal conductance of a building. The actual framing fraction should be calculated for each specific construction.

Table 3 Thermal Resistances of Plane Air Spaces[a,b,c], °F·ft²·h/Btu

Position of Air Space	Direction of Heat Flow	Air Space Mean Temp.[d], °F	Air Space Temp. Diff.[d], °F	0.5-in. Air Space[c] Effective Emittance ε_{eff}[d,e] 0.03	0.05	0.2	0.5	0.82	0.75-in. Air Space[c] Effective Emittance ε_{eff}[d,e] 0.03	0.05	0.2	0.5	0.82
Horiz.	Up	90	10	2.13	2.03	1.51	0.99	0.73	2.34	2.22	1.61	1.04	0.75
		50	30	1.62	1.57	1.29	0.96	0.75	1.71	1.66	1.35	0.99	0.77
		50	10	2.13	2.05	1.60	1.11	0.84	2.30	2.21	1.70	1.16	0.87
		0	20	1.73	1.70	1.45	1.12	0.91	1.83	1.79	1.52	1.16	0.93
		0	10	2.10	2.04	1.70	1.27	1.00	2.23	2.16	1.78	1.31	1.02
		−50	20	1.69	1.66	1.49	1.23	1.04	1.77	1.74	1.55	1.27	1.07
		−50	10	2.04	2.00	1.75	1.40	1.16	2.16	2.11	1.84	1.46	1.20
45° Slope	Up	90	10	2.44	2.31	1.65	1.06	0.76	2.96	2.78	1.88	1.15	0.81
		50	30	2.06	1.98	1.56	1.10	0.83	1.99	1.92	1.52	1.08	0.82
		50	10	2.55	2.44	1.83	1.22	0.90	2.90	2.75	2.00	1.29	0.94
		0	20	2.20	2.14	1.76	1.30	1.02	2.13	2.07	1.72	1.28	1.00
		0	10	2.63	2.54	2.03	1.44	1.10	2.72	2.62	2.08	1.47	1.12
		−50	20	2.08	2.04	1.78	1.42	1.17	2.05	2.01	1.76	1.41	1.16
		−50	10	2.62	2.56	2.17	1.66	1.33	2.53	2.47	2.10	1.62	1.30
Vertical	Horiz.	90	10	2.47	2.34	1.67	1.06	0.77	3.50	3.24	2.08	1.22	0.84
		50	30	2.57	2.46	1.84	1.23	0.90	2.91	2.77	2.01	1.30	0.94
		50	10	2.66	2.54	1.88	1.24	0.91	3.70	3.46	2.35	1.43	1.01
		0	20	2.82	2.72	2.14	1.50	1.13	3.14	3.02	2.32	1.58	1.18
		0	10	2.93	2.82	2.20	1.53	1.15	3.77	3.59	2.64	1.73	1.26
		−50	20	2.90	2.82	2.35	1.76	1.39	2.90	2.83	2.36	1.77	1.39
		−50	10	3.20	3.10	2.54	1.87	1.46	3.72	3.60	2.87	2.04	1.56
45° Slope	Down	90	10	2.48	2.34	1.67	1.06	0.77	3.53	3.27	2.10	1.22	0.84
		50	30	2.64	2.52	1.87	1.24	0.91	3.43	3.23	2.24	1.39	0.99
		50	10	2.67	2.55	1.89	1.25	0.92	3.81	3.57	2.40	1.45	1.02
		0	20	2.91	2.80	2.19	1.52	1.15	3.75	3.57	2.63	1.72	1.26
		0	10	2.94	2.83	2.21	1.53	1.15	4.12	3.91	2.81	1.80	1.30
		−50	20	3.16	3.07	2.52	1.86	1.45	3.78	3.65	2.90	2.05	1.57
		−50	10	3.26	3.16	2.58	1.89	1.47	4.35	4.18	3.22	2.21	1.66
Horiz.	Down	90	10	2.48	2.34	1.67	1.06	0.77	3.55	3.29	2.10	1.22	0.85
		50	30	2.66	2.54	1.88	1.24	0.91	3.77	3.52	2.38	1.44	1.02
		50	10	2.67	2.55	1.89	1.25	0.92	3.84	3.59	2.41	1.45	1.02
		0	20	2.94	2.83	2.20	1.53	1.15	4.18	3.96	2.83	1.81	1.30
		0	10	2.96	2.85	2.22	1.53	1.16	4.25	4.02	2.87	1.82	1.31
		−50	20	3.25	3.15	2.58	1.89	1.47	4.60	4.41	3.36	2.28	1.69
		−50	10	3.28	3.18	2.60	1.90	1.47	4.71	4.51	3.42	2.30	1.71
		Air Space		**1.5-in. Air Space[c]**					**3.5-in. Air Space[c]**				
Horiz.	Up	90	10	2.55	2.41	1.71	1.08	0.77	2.84	2.66	1.83	1.13	0.80
		50	30	1.87	1.81	1.45	1.04	0.80	2.09	2.01	1.58	1.10	0.84
		50	10	2.50	2.40	1.81	1.21	0.89	2.80	2.66	1.95	1.28	0.93
		0	20	2.01	1.95	1.63	1.23	0.97	2.25	2.18	1.79	1.32	1.03
		0	10	2.43	2.35	1.90	1.38	1.06	2.71	2.62	2.07	1.47	1.12
		−50	20	1.94	1.91	1.68	1.36	1.13	2.19	2.14	1.86	1.47	1.20
		−50	10	2.37	2.31	1.99	1.55	1.26	2.65	2.58	2.18	1.67	1.33
45° Slope	Up	90	10	2.92	2.73	1.86	1.14	0.80	3.18	2.96	1.97	1.18	0.82
		50	30	2.14	2.06	1.61	1.12	0.84	2.26	2.17	1.67	1.15	0.86
		50	10	2.88	2.74	1.99	1.29	0.94	3.12	2.95	2.10	1.34	0.96
		0	20	2.30	2.23	1.82	1.34	1.04	2.42	2.35	1.90	1.38	1.06
		0	10	2.79	2.69	2.12	1.49	1.13	2.98	2.87	2.23	1.54	1.16
		−50	20	2.22	2.17	1.88	1.49	1.21	2.34	2.29	1.97	1.54	1.25
		−50	10	2.71	2.64	2.23	1.69	1.35	2.87	2.79	2.33	1.75	1.39
Vertical	Horiz.	90	10	3.99	3.66	2.25	1.27	0.87	3.69	3.40	2.15	1.24	0.85
		50	30	2.58	2.46	1.84	1.23	0.90	2.67	2.55	1.89	1.25	0.91
		50	10	3.79	3.55	2.39	1.45	1.02	3.63	3.40	2.32	1.42	1.01
		0	20	2.76	2.66	2.10	1.48	1.12	2.88	2.78	2.17	1.51	1.14
		0	10	3.51	3.35	2.51	1.67	1.23	3.49	3.33	2.50	1.67	1.23
		−50	20	2.64	2.58	2.18	1.66	1.33	2.82	2.75	2.30	1.73	1.37
		−50	10	3.31	3.21	2.62	1.91	1.48	3.40	3.30	2.67	1.94	1.50
45° Slope	Down	90	10	5.07	4.55	2.56	1.36	0.91	4.81	4.33	2.49	1.34	0.90
		50	30	3.58	3.36	2.31	1.42	1.00	3.51	3.30	2.28	1.40	1.00
		50	10	5.10	4.66	2.85	1.60	1.09	4.74	4.36	2.73	1.57	1.08
		0	20	3.85	3.66	2.68	1.74	1.27	3.81	3.63	2.66	1.74	1.27
		0	10	4.92	4.62	3.16	1.94	1.37	4.59	4.32	3.02	1.88	1.34
		−50	20	3.62	3.50	2.80	2.01	1.54	3.77	3.64	2.90	2.05	1.57
		−50	10	4.67	4.47	3.40	2.29	1.70	4.50	4.32	3.31	2.25	1.68
Horiz.	Down	90	10	6.09	5.35	2.79	1.43	0.94	10.07	8.19	3.41	1.57	1.00
		50	30	6.27	5.63	3.18	1.70	1.14	9.60	8.17	3.86	1.88	1.22
		50	10	6.61	5.90	3.27	1.73	1.15	11.15	9.27	4.09	1.93	1.24
		0	20	7.03	6.43	3.91	2.19	1.49	10.90	9.52	4.87	2.47	1.62
		0	10	7.31	6.66	4.00	2.22	1.51	11.97	10.32	5.08	2.52	1.64
		−50	20	7.73	7.20	4.77	2.85	1.99	11.64	10.49	6.02	3.25	2.18
		−50	10	8.09	7.52	4.91	2.89	2.01	12.98	11.56	6.36	3.34	2.22

[a]See Chapter 22, section Factors Affecting Heat Transfer across Air Spaces. Thermal resistance values were determined from the relation, $R = 1/C$, where $C = h_c + \varepsilon_{eff} h_r$, h_c is the conduction-convection coefficient, $\varepsilon_{eff} h_r$ is the radiation coefficient $\approx 0.0068\varepsilon_{eff}[(t_m + 460)/100]^3$, and t_m is the mean temperature of the air space. Values for h_c were determined from data developed by Robinson et al. (1954). Equations (5) through (7) in Yarbrough (1983) show the data in this table in analytic form. For extrapolation from this table to air spaces less than 0.5 in. (as in insulating window glass), assume $h_c = 0.159(1 + 0.0016\, t_m)/l$ where l is the air space thickness in inches, and h_c is heat transfer through the air space only.

[b]Values are based on data presented by Robinson et al. (1954). (Also see Chapter 3, Tables 3 and 4, and Chapter 36). Values apply for ideal conditions, i.e., air spaces of uniform thickness bounded by plane, smooth, parallel surfaces with no air leakage to or from the space. When accurate values are required, use overall U-factors determined through calibrated hot box (ASTM C 976) or guarded hot box (ASTM C 236) testing. Thermal resistance values for multiple air spaces must be based on careful estimates of mean temperature differences for each air space.

[c]A single resistance value cannot account for multiple air spaces; each air space requires a separate resistance calculation that applies only for the established boundary conditions. Resistances of horizontal spaces with heat flow downward are substantially independent of temperature difference.

[d]Interpolation is permissible for other values of mean temperature, temperature difference, and effective emittance ε_{eff}. Interpolation and moderate extrapolation for air spaces greater than 3.5 in. are also permissible.

[e]Effective emittance ε_{eff} of the air space is given by $1/\varepsilon_{eff} = 1/\varepsilon_1 + 1/\varepsilon_2 - 1$, where ε_1 and ε_2 are the emittances of the surfaces of the air space (see Table 2).

Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values[a]

Description	Density, lb/ft³	Conductivity[b] (k), Btu·in/h·ft²·°F	Conductance (C), Btu/h·ft²·°F	Resistance[c] (R) Per Inch Thickness (1/k), °F·ft²·h/Btu·in	Resistance[c] (R) For Thickness Listed (1/C), °F·ft²·h/Btu	Specific Heat, Btu/lb·°F
BUILDING BOARD						
Asbestos-cement board	120	4.0	—	0.25	—	0.24
Asbestos-cement board 0.125 in.	120	—	33.00	—	0.03	
Asbestos-cement board 0.25 in.	120	—	16.50	—	0.06	
Gypsum or plaster board 0.375 in.	50	—	3.10	—	0.32	0.26
Gypsum or plaster board 0.5 in.	50	—	2.22	—	0.45	
Gypsum or plaster board 0.625 in.	50	—	1.78	—	0.56	
Plywood (Douglas Fir)[d]	34	0.80	—	1.25	—	0.29
Plywood (Douglas Fir) 0.25 in.	34	—	3.20	—	0.31	
Plywood (Douglas Fir) 0.375 in.	34	—	2.13	—	0.47	
Plywood (Douglas Fir) 0.5 in.	34	—	1.60	—	0.62	
Plywood (Douglas Fir) 0.625 in.	34	—	1.29	—	0.77	
Plywood or wood panels 0.75 in.	34	—	1.07	—	0.93	0.29
Vegetable fiber board						
Sheathing, regular density[e] 0.5 in.	18	—	0.76	—	1.32	0.31
0.78125 in.	18	—	0.49	—	2.06	
Sheathing intermediate density[e] 0.5 in.	22	—	0.92	—	1.09	0.31
Nail-base sheathing[e] 0.5 in.	25	—	0.94	—	1.06	0.31
Shingle backer 0.375 in.	18	—	1.06	—	0.94	0.31
Shingle backer 0.3125 in.	18	—	1.28	—	0.78	
Sound deadening board 0.5 in.	15	—	0.74	—	1.35	0.30
Tile and lay-in panels, plain or acoustic	18	0.40	—	2.50	—	0.14
0.5 in.	18	—	0.80	—	1.25	
0.75 in.	18	—	0.53	—	1.89	
Laminated paperboard	30	0.50	—	2.00	—	0.33
Homogeneous board from repulped paper	30	0.50	—	2.00	—	0.28
Hardboard[e]						
Medium density	50	0.73	—	1.37	—	0.31
High density, service-tempered grade and service grade	55	0.82	—	1.22	—	0.32
High density, standard-tempered grade	63	1.00	—	1.00	—	0.32
Particleboard[e]						
Low density	37	0.71	—	1.41	—	0.31
Medium density	50	0.94	—	1.06	—	0.31
High density	62	.5	1.18	—	0.85	—
Underlayment 0.625 in.	40	—	1.22	—	0.82	0.29
Waferboard	37	0.63	—	1.59	—	—
Wood subfloor 0.75 in.	—	—	1.06	—	0.94	0.33
BUILDING MEMBRANE						
Vapor—permeable felt	—	—	16.70	—	0.06	
Vapor—seal, 2 layers of mopped 15-lb felt	—	—	8.35	—	0.12	
Vapor—seal, plastic film	—	—	—	—	Negl.	
FINISH FLOORING MATERIALS						
Carpet and fibrous pad	—	—	0.48	—	2.08	0.34
Carpet and rubber pad	—	—	0.81	—	1.23	0.33
Cork tile 0.125 in.	—	—	3.60	—	0.28	0.48
Terrazzo 1 in.	—	—	12.50	—	0.08	0.19
Tile—asphalt, linoleum, vinyl, rubber	—	—	20.00	—	0.05	0.30
vinyl asbestos						0.24
ceramic						0.19
Wood, hardwood finish 0.75 in.	—	—	1.47	—	0.68	
INSULATING MATERIALS						
Blanket and Batt[f,g]						
Mineral fiber, fibrous form processed from rock, slag, or glass						
approx. 3-4 in.	0.4-2.0	—	0.091	—	11	
approx. 3.5 in.	0.4-2.0	—	0.077	—	13	
approx. 3.5 in.	1.2-1.6	—	0.067	—	15	
approx. 5.5-6.5 in.	0.4-2.0	—	0.053	—	19	
approx. 5.5 in.	0.6-1.0	—	0.048	—	21	
approx. 6-7.5 in.	0.4-2.0	—	0.045	—	22	
approx. 8.25-10 in.	0.4-2.0	—	0.033	—	30	
approx. 10-13 in.	0.4-2.0	—	0.026	—	38	
Board and Slabs						
Cellular glass	8.0	0.33	—	3.03	—	0.18
Glass fiber, organic bonded	4.0-9.0	0.25	—	4.00	—	0.23
Expanded perlite, organic bonded	1.0	0.36	—	2.78	—	0.30
Expanded rubber (rigid)	4.5	0.22	—	4.55	—	0.40
Expanded polystyrene, extruded (smooth skin surface) (CFC-12 exp.)	1.8-3.5	0.20	—	5.00	—	0.29

Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values[a] (Continued)

Description	Density, lb/ft³	Conductivity[b] (k), Btu·in/h·ft²·°F	Conductance (C), Btu/h·ft²·°F	Resistance[c] (R) Per Inch Thickness (1/k), °F·ft²·h/Btu·in	Resistance[c] (R) For Thickness Listed (1/C), °F·ft²·h/Btu	Specific Heat, Btu/lb·°F
Expanded polystyrene, extruded (smooth skin surface) (HCFC-142b exp.)[h]	1.8-3.5	0.20	—	5.00	—	0.29
Expanded polystyrene, molded beads	1.0	0.26	—	3.85	—	—
	1.25	0.25	—	4.00	—	—
	1.5	0.24	—	4.17	—	—
	1.75	0.24	—	4.17	—	—
	2.0	0.23	—	4.35	—	—
Cellular polyurethane/polyisocyanurate[i] (CFC-11 exp.) (unfaced)	1.5	0.16-0.18	—	6.25-5.56	—	0.38
Cellular polyisocyanurate[i] (CFC-11 exp.) (gas-permeable facers)	1.5-2.5	0.16-0.18	—	6.25-5.56	—	0.22
Cellular polyisocyanurate[j] (CFC-11 exp.) (gas-impermeable facers)	2.0	0.14	—	7.04	—	0.22
Cellular phenolic (closed cell) (CFC-11, CFC-113 exp.)[k]	3.0	0.12	—	8.20	—	—
Cellular phenolic (open cell)	1.8-2.2	0.23	—	4.40	—	—
Mineral fiber with resin binder	15.0	0.29	—	3.45	—	0.17
Mineral fiberboard, wet felted						
Core or roof insulation	16-17	0.34	—	2.94	—	—
Acoustical tile	18.0	0.35	—	2.86	—	0.19
Acoustical tile	21.0	0.37	—	2.70	—	—
Mineral fiberboard, wet molded						
Acoustical tile[l]	23.0	0.42	—	2.38	—	0.14
Wood or cane fiberboard						
Acoustical tile[l] 0.5 in.	—	—	0.80	—	1.25	0.31
Acoustical tile[l] 0.75 in.	—	—	0.53	—	1.89	—
Interior finish (plank, tile)	15.0	0.35	—	2.86	—	0.32
Cement fiber slabs (shredded wood with Portland cement binder)	25-27.0	0.50-0.53		2.0-1.89	—	
Cement fiber slabs (shredded wood with magnesia oxysulfide binder)	22.0	0.57	—	1.75	—	0.31
Loose Fill						
Cellulosic insulation (milled paper or wood pulp)	2.3-3.2	0.27-0.32	—	3.70-3.13	—	0.33
Perlite, expanded	2.0-4.1	0.27-0.31	—	3.7-3.3	—	0.26
	4.1-7.4	0.31-0.36	—	3.3-2.8	—	—
	7.4-11.0	0.36-0.42	—	2.8-2.4	—	—
Mineral fiber (rock, slag, or glass)[g]						
approx. 3.75-5 in.	0.6-2.0	—	—	—	11.0	0.17
approx. 6.5-8.75 in.	0.6-2.0	—	—	—	19.0	—
approx. 7.5-10 in.	0.6-2.0	—	—	—	22.0	—
approx. 10.25-13.75 in.	0.6-2.0	—	—	—	30.0	—
Mineral fiber (rock, slag, or glass)[g]						
approx. 3.5 in. (closed sidewall application)	2.0-3.5	—	—	—	12.0-14.0	—
Vermiculite, exfoliated	7.0-8.2	0.47	—	2.13	—	0.32
	4.0-6.0	0.44	—	2.27	—	—
Spray Applied						
Polyurethane foam	1.5-2.5	0.16-0.18	—	6.25-5.56	—	—
Ureaformaldehyde foam	0.7-1.6	0.22-0.28	—	4.55-3.57	—	—
Cellulosic fiber	3.5-6.0	0.29-0.34	—	3.45-2.94	—	—
Glass fiber	3.5-4.5	0.26-0.27	—	3.85-3.70	—	—
Reflective Insulation						
Reflective material ($\varepsilon < 0.5$) in center of 3/4 in. cavity forms two 3/8 in. vertical air spaces[m]	—	—	0.31	—	3.2	—
METALS (See Chapter 36, Table 3)						
ROOFING						
Asbestos-cement shingles	120	—	4.76	—	0.21	0.24
Asphalt roll roofing	70	—	6.50	—	0.15	0.36
Asphalt shingles	70	—	2.27	—	0.44	0.30
Built-up roofing 0.375 in.	70	—	3.00	—	0.33	0.35
Slate 0.5 in.	—	—	20.00	—	0.05	0.30
Wood shingles, plain and plastic film faced	—	—	1.06	—	0.94	0.31
PLASTERING MATERIALS						
Cement plaster, sand aggregate	116	5.0	—	0.20	—	0.20
Sand aggregate 0.375 in.	—	—	13.3	—	0.08	0.20
Sand aggregate 0.75 in.	—	—	6.66	—	0.15	0.20

Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values[a] (Continued)

Description	Density, lb/ft³	Conductivity[b] (k), Btu·in/(h·ft²·°F)	Conductance (C), Btu/(h·ft²·°F)	Resistance[c] (R) Per Inch Thickness (1/k), °F·ft²·h/(Btu·in)	Resistance[c] (R) For Thickness Listed (1/C), °F·ft²·h/Btu	Specific Heat, Btu/(lb·°F)
Gypsum plaster:						
Lightweight aggregate ... 0.5 in.	45	—	3.12	—	0.32	—
Lightweight aggregate ... 0.625 in.	45	—	2.67	—	0.39	—
Lightweight aggregate on metal lath ... 0.75 in.	—	—	2.13	—	0.47	—
Perlite aggregate	45	1.5	—	0.67	—	0.32
Sand aggregate	105	5.6	—	0.18	—	0.20
Sand aggregate ... 0.5 in.	105	—	11.10	—	0.09	—
Sand aggregate ... 0.625 in.	105	—	9.10	—	0.11	—
Sand aggregate on metal lath ... 0.75 in.	—	—	7.70	—	0.13	—
Vermiculite aggregate	45	1.7	—	0.59	—	—
MASONRY MATERIALS						
Masonry Units						
Brick, fired clay	150	8.4-10.2	—	0.12-0.10	—	—
	140	7.4-9.0	—	0.14-0.11	—	—
	130	6.4-7.8	—	0.16-0.12	—	—
	120	5.6-6.8	—	0.18-0.15	—	0.19
	110	4.9-5.9	—	0.20-0.17	—	—
	100	4.2-5.1	—	0.24-0.20	—	—
	90	3.6-4.3	—	0.28-0.24	—	—
	80	3.0-3.7	—	0.33-0.27	—	—
	70	2.5-3.1	—	0.40-0.33	—	—
Clay tile, hollow						
1 cell deep ... 3 in.	—	—	1.25	—	0.80	0.21
1 cell deep ... 4 in.	—	—	0.90	—	1.11	—
2 cells deep ... 6 in.	—	—	0.66	—	1.52	—
2 cells deep ... 8 in.	—	—	0.54	—	1.85	—
2 cells deep ... 10 in.	—	—	0.45	—	2.22	—
3 cells deep ... 12 in.	—	—	0.40	—	2.50	—
Concrete blocks[n, o]						
Limestone aggregate						
8 in., 36 lb, 138 lb/ft³ concrete, 2 cores	—	—	—	—	—	—
Same with perlite filled cores	—	—	0.48	—	2.1	—
12 in., 55 lb, 138 lb/ft³ concrete, 2 cores	—	—	—	—	—	—
Same with perlite filled cores	—	—	0.27	—	3.7	—
Normal weight aggregate (sand and gravel)						
8 in., 33-36 lb, 126-136 lb/ft³ concrete, 2 or 3 cores	—	—	0.90-1.03	—	1.11-0.97	0.22
Same with perlite filled cores	—	—	0.50	—	2.0	—
Same with vermiculite filled cores	—	—	0.52-0.73	—	1.92-1.37	—
12 in., 50 lb, 125 lb/ft³ concrete, 2 cores	—	—	0.81	—	1.23	0.22
Medium weight aggregate (combinations of normal weight and lightweight aggregate)						
8 in., 26-29 lb, 97-112 lb/ft³ concrete, 2 or 3 cores	—	—	0.58-0.78	—	1.71-1.28	—
Same with perlite filled cores	—	—	0.27-0.44	—	3.7-2.3	—
Same with vermiculite filled cores	—	—	0.30	—	3.3	—
Same with molded EPS (beads) filled cores	—	—	0.32	—	3.2	—
Same with molded EPS inserts in cores	—	—	0.37	—	2.7	—
Lightweight aggregate (expanded shale, clay, slate or slag, pumice)						
6 in., 16-17 lb 85-87 lb/ft³ concrete, 2 or 3 cores	—	—	0.52-0.61	—	1.93-1.65	—
Same with perlite filled cores	—	—	0.24	—	4.2	—
Same with vermiculite filled cores	—	—	0.33	—	3.0	—
8 in., 19-22 lb, 72-86 lb/ft³ concrete	—	—	0.32-0.54	—	3.2-1.90	0.21
Same with perlite filled cores	—	—	0.15-0.23	—	6.8-4.4	—
Same with vermiculite filled cores	—	—	0.19-0.26	—	5.3-3.9	—
Same with molded EPS (beads) filled cores	—	—	0.21	—	4.8	—
Same with UF foam filled cores	—	—	0.22	—	4.5	—
Same with molded EPS inserts in cores	—	—	0.29	—	3.5	—
12 in., 32-36 lb, 80-90 lb/ft³ concrete, 2 or 3 cores	—	—	0.38-0.44	—	2.6-2.3	—
Same with perlite filled cores	—	—	0.11-0.16	—	9.2-6.3	—
Same with vermiculite filled cores	—	—	0.17	—	5.8	—
Stone, lime, or sand	180	72	—	0.01	—	—
Quartzitic and sandstone	160	43	—	0.02	—	—
	140	24	—	0.04	—	—
	120	13	—	0.08	—	0.19
Calcitic, dolomitic, limestone, marble, and granite	180	30	—	0.03	—	—
	160	22	—	0.05	—	—
	140	16	—	0.06	—	—
	120	11	—	0.09	—	0.19
	100	8	—	0.13	—	—

Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values[a] (Continued)

Description	Density, lb/ft³	Conductivity[b] (k), Btu·in / h·ft²·°F	Conductance (C), Btu / h·ft²·°F	Resistance[c] (R): Per Inch Thickness (1/k), °F·ft²·h / Btu·in	Resistance[c] (R): For Thickness Listed (1/C), °F·ft²·h / Btu	Specific Heat, Btu / lb·°F
Gypsum partition tile						
3 by 12 by 30 in., solid	—	—	0.79	—	1.26	0.19
3 by 12 by 30 in., 4 cells	—	—	0.74	—	1.35	—
4 by 12 by 30 in., 3 cells	—	—	0.60	—	1.67	—
Concretes[d]						
Sand and gravel or stone aggregate concretes (concretes with more than 50% quartz or quartzite sand have conductivities in the higher end of the range)	150	10.0-20.0	—	0.10-0.05	—	—
	140	9.0-18.0	—	0.11-0.06	—	0.19-0.24
	130	7.0-13.0	—	0.14-0.08	—	—
Limestone concretes	140	11.1	—	0.09	—	—
	120	7.9	—	0.13	—	—
	100	5.5	—	0.18	—	—
Gypsum-fiber concrete (87.5% gypsum, 12.5% wood chips)	51	1.66	—	0.60	—	0.21
Cement/lime, mortar, and stucco	120	9.7	—	0.10	—	—
	100	6.7	—	0.15	—	—
	80	4.5	—	0.22	—	—
Lightweight aggregate concretes						
Expanded shale, clay, or slate; expanded slags; cinders; pumice (with density up to 100 lb/ft³); and scoria (sanded concretes have conductivities in the higher end of the range)	120	6.4-9.1	—	0.16-0.11	—	—
	100	4.7-6.2	—	0.21-0.16	—	0.20
	80	3.3-4.1	—	0.30-0.24	—	0.20
	60	2.1-2.5	—	0.48-0.40	—	—
	40	1.3	—	0.78	—	—
Perlite, vermiculite, and polystyrene beads	50	1.8-1.9	—	0.55-0.53	—	—
	40	1.4-1.5	—	0.71-0.67	—	0.15-0.23
	30	1.1	—	0.91	—	—
	20	0.8	—	1.25	—	—
Foam concretes	120	5.4	—	0.19	—	—
	100	4.1	—	0.24	—	—
	80	3.0	—	0.33	—	—
	70	2.5	—	0.40	—	—
Foam concretes and cellular concretes	60	2.1	—	0.48	—	—
	40	1.4	—	0.71	—	—
	20	0.8	—	1.25	—	—
SIDING MATERIALS (on flat surface)						
Shingles						
Asbestos-cement	120	—	4.75	—	0.21	—
Wood, 16 in., 7.5 exposure	—	—	1.15	—	0.87	0.31
Wood, double, 16-in., 12-in. exposure	—	—	0.84	—	1.19	0.28
Wood, plus ins. backer board, 0.312 in.	—	—	0.71	—	1.40	0.31
Siding						
Asbestos-cement, 0.25 in., lapped	—	—	4.76	—	0.21	0.24
Asphalt roll siding	—	—	6.50	—	0.15	0.35
Asphalt insulating siding (0.5 in. bed.)	—	—	0.69	—	1.46	0.35
Hardboard siding, 0.4375 in.	—	—	1.49	—	0.67	0.28
Wood, drop, 1 by 8 in.	—	—	1.27	—	0.79	0.28
Wood, bevel, 0.5 by 8 in., lapped	—	—	1.23	—	0.81	0.28
Wood, bevel, 0.75 by 10 in., lapped	—	—	0.95	—	1.05	0.28
Wood, plywood, 0.375 in., lapped	—	—	1.69	—	0.59	0.29
Aluminum, steel, or vinyl[p,q], over sheathing						
Hollow-backed	—	—	1.64	—	0.61	0.29[q]
Insulating-board backed nominal 0.375 in.	—	—	0.55	—	1.82	0.32
Insulating-board backed nominal 0.375 in., foil backed	—	—	0.34	—	2.96	—
Architectural (soda-lime float) glass	158	6.9	—	—	—	0.21
WOODS (12% moisture content)[e,r]						
Hardwoods						0.39[s]
Oak	41.2-46.8	1.12-1.25	—	0.89-0.80	—	
Birch	42.6-45.4	1.16-1.22	—	0.87-0.82	—	
Maple	39.8-44.0	1.09-1.19	—	0.92-0.84	—	
Ash	38.4-41.9	1.06-1.14	—	0.94-0.88	—	
Softwoods						0.39[s]
Southern Pine	35.6-41.2	1.00-1.12	—	1.00-0.89	—	
Douglas Fir-Larch	33.5-36.3	0.95-1.01	—	1.06-0.99	—	
Southern Cypress	31.4-32.1	0.90-0.92	—	1.11-1.09	—	
Hem-Fir, Spruce-Pine-Fir	24.5-31.4	0.74-0.90	—	1.35-1.11	—	
West Coast Woods, Cedars	21.7-31.4	0.68-0.90	—	1.48-1.11	—	
California Redwood	24.5-28.0	0.74-0.82	—	1.35-1.22	—	

Notes for Table 4

[a]Values are for a mean temperature of 75°F. Representative values for dry materials are intended as design (not specification) values for materials in normal use. Thermal values of insulating materials may differ from design values depending on their in-situ properties (e.g., density and moisture content, orientation, etc.) and variability experienced during manufacture. For properties of a particular product, use the value supplied by the manufacturer or by unbiased tests.

[b]To obtain thermal conductivities in Btu/h·ft·°F, divide the *k*-factor by 12 in/ft.

[c]Resistance values are the reciprocals of *C* before rounding off *C* to two decimal places.

[d]Lewis (1967).

[e]U.S. Department of Agriculture (1974).

[f]Does not include paper backing and facing, if any. Where insulation forms a boundary (reflective or otherwise) of an airspace, see Tables 2 and 3 for the insulating value of an airspace with the appropriate effective emittance and temperature conditions of the space.

[g]Conductivity varies with fiber diameter. (See Chapter 22, Factors Affecting Thermal Performance.) Batt, blanket, and loose-fill mineral fiber insulations are manufactured to achieve specified R-values, the most common of which are listed in the table. Due to differences in manufacturing processes and materials, the product thicknesses, densities, and thermal conductivities vary over considerable ranges for a specified R-value.

[h]This material is relatively new and data are based on limited testing.

[i]For additional information, see Society of Plastics Engineers (SPI) *Bulletin* U108. Values are for aged, unfaced board stock. For change in conductivity with age of expanded polyurethane/polyisocyanurate, see Chapter 22, Factors Affecting Thermal Performance.

[j]Values are for aged products with gas-impermeable facers on the two major surfaces. An aluminum foil facer of 0.001 in. thickness or greater is generally considered impermeable to gases. For change in conductivity with age of expanded polyisocyanurate, see Chapter 22, Factors Affecting Thermal Performance, and SPI *Bulletin* U108.

[k]Cellular phenolic insulation may no longer be manufactured. The thermal conductivity and resistance values do not represent aged insulation, which may have a higher thermal conductivity and lower thermal resistance.

[l]Insulating values of acoustical tile vary, depending on density of the board and on type, size, and depth of perforations.

[m]Cavity is framed with 0.75 in. wood furring strips. Caution should be used in applying this value for other framing materials. The reported value was derived from tests and applies to the reflective path only. The effect of studs or furring strips must be included in determining the overall performance of the wall.

[n]Values for fully grouted block may be approximated using values for concrete with a similar unit weight.

[o]Values for concrete block and concrete are at moisture contents representative of normal use.

[p]Values for metal or vinyl siding applied over flat surfaces vary widely, depending on amount of ventilation of airspace beneath the siding; whether airspace is reflective or nonreflective; and on thickness, type, and application of insulating backing used. Values are averages for use as design guides, and were obtained from several guarded hot box tests (ASTM C 236) or calibrated hot box (ASTM C 976) on hollow-backed types and types made using backing-boards of wood fiber, foamed plastic, and glass fiber. Departures of ±50% or more from these values may occur.

[q]Vinyl specific heat = 0.25 Btu/lb·°F

[r]See Adams (1971), MacLean (1941), and Wilkes (1979). The conductivity values listed are for heat transfer across the grain. The thermal conductivity of wood varies linearly with the density, and the density ranges listed are those normally found for the wood species given. If the density of the wood species is not known, use the mean conductivity value. For extrapolation to other moisture contents, the following empirical equation developed by Wilkes (1979) may be used:

$$k = 0.1791 + \frac{(1.874 \times 10^{-2} + 5.753 \times 10^{-4} M)\rho}{1 + 0.01M}$$

where ρ is density of the moist wood in lb/ft^3, and M is the moisture content in percent.

[s]From Wilkes (1979), an empirical equation for the specific heat of moist wood at 75°F is as follows:

$$c_p = \frac{(0.299 + 0.01M)}{(1 + 0.01M)} + \Delta c_p$$

where Δc_p accounts for the heat of sorption and is denoted by

$$\Delta c_p = M(1.921 \times 10^{-3} - 3.168 \times 10^{-5} M)$$

where M is the moisture content in percent by mass.

Example 1. Calculate the U-factor of the 2 by 4 stud wall shown in Figure 2. The studs are at 16 in. OC. There is 3.5 in. mineral fiber batt insulation (R-13) in the stud space. The inside finish is 0.5 in. gypsum wallboard; the outside is finished with rigid foam insulating sheathing (R-4) and 0.5 in. by 8 in. wood bevel lapped siding. The insulated cavity occupies approximately 75% of the transmission area; the studs, plates, and sills occupy 21%; and the headers occupy 4%.

Solution. Obtain the R-values of the various building elements from Tables 1 and 4. Assume the R = 1.25 per inch for the wood framing. Also, assume the headers are solid wood, in this case, and group them with the studs, plates, and sills.

Element	*R* (Insulated Cavity)	*R* (Studs, Plates, and Headers)
1. Outside surface, 15 mphwind	0.17	0.17
2. Wood bevel lapped siding	0.81	0.81
3. Rigid foam insulating sheathing	4.0	4.0
4. Mineral fiber batt insulation, 3.5 in.	13.0	—
5. Wood stud, nominal 2 × 4	—	4.38
6. Gypsum wallboard, 0.5 in.	0.45	0.45
7. Inside surface, still air	0.68	0.68
	R_1 = 19.11	R_2 = 10.49

Since the U-factor is the reciprocal of R-value, U_1 = 0.052 and U_2 = 0.095 Btu/h·ft^2·°F.

If the wood framing (thermal bridging) is not included, Equation (3) from Chapter 22 may be used to calculate the U-factor of the wall as follows:

$$U_{av} = U_1 = \frac{1}{R_1} = 0.052 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^\circ\text{F}$$

If the wood framing is accounted for using the parallel-path flow method, the U-factor of the wall is determined using Equation (5) from Chapter 22 as follows:

$$U_{av} = (0.75 \times 0.052) + (0.25 \times 0.095) = 0.063 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^\circ\text{F}$$

If the wood framing is included using the isothermal planes method, the U-factor of the wall is determined using Equations (2) and (3) from Chapter 22 as follows:

$$R_{T(av)} = 4.98 + 1/[(0.75/13.0) + (0.25/4.38)] + 1.13$$

$$= 14.82 {}^\circ\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$$

$$U_{av} = 0.067 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^\circ\text{F}$$

For a frame wall with a 24-in. OC stud space, the average overall R-value is 15.18°F·ft^2·h/Btu. Similar calculation procedures may be used to evaluate other wall designs, except those with thermal bridges.

Masonry Walls

The average overall R-values of masonry walls can be estimated by assuming a combination of layers in series, one or more of which provides parallel paths. This method is used because heat flows laterally through block face shells so that transverse isothermal planes result. Average total resistance $R_{T(av)}$ is the sum of the resistances of the layers between such planes, each layer calculated as shown in Example 2.

Example 2. Calculate the overall thermal resistance and average U-factor of the 7-5/8-in. thick insulated concrete block wall shown in Figure 3. The two-core block has an average web thickness of 1-in. and a face shell thickness of 1-1/4-in. Overall block dimensions are 7-5/8 by 7-5/8 by 15-5/8 in. Measured thermal resistances of 112 lb/ft^3 concrete and 7 lb/ft^3 expanded perlite insulation are 0.10 and 2.90°F·ft^2·h/Btu per inch, respectively.

Solution. The equation used to determine the overall thermal resistance of the insulated concrete block wall is derived from Equations (2) and (5) from Chapter 22 and is given below:

$$R_{T(av)} = R_i + R_f + \left(\frac{a_w}{R_w} + \frac{a_c}{R_c}\right)^{-1} + R_o$$

where

$R_{T(av)}$ = overall thermal resistance based on assumption of isothermal planes
R_i = thermal resistance of inside air surface film (still air)
R_o = thermal resistance of outside air surface film (15 mph wind)
R_f = total thermal resistance of face shells
R_c = thermal resistance of cores between face shells
R_w = thermal resistance of webs between face shells
a_w = fraction of total area transverse to heat flow represented by webs of blocks
a_c = fraction of total area transverse to heat flow represented by cores of blocks

From the information given and the data in Table 1, determine the values needed to compute the overall thermal resistance.

R_i = 0.68
R_o = 0.17
R_f = (2)(1.25)(0.10) = 0.25
R_c = (5.125)(2.90) = 14.86
R_w = (5.125)(0.10) = 0.51
a_w = 3/15.625 = 0.192
a_c = 12.625/15.625 = 0.808

Using the equation given, the overall thermal resistance and average U-factor are calculated as follows:

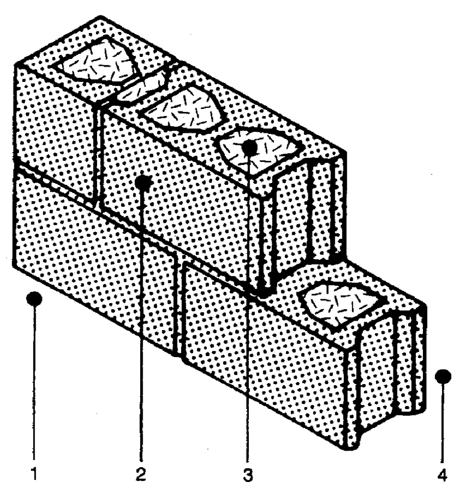


Fig. 3 Insulated Concrete Block Wall (Example 2)

$$R_{T(av)} = 0.68 + 0.25 + \frac{0.51 \times 14.86}{(0.808 \times 0.51) + (0.192 \times 14.86)} + 0.17$$

$$= 3.43\text{°F} \cdot \text{ft}^2 \cdot \text{h/Btu}$$

$$U_{av} = 1/3.43 = 0.29 \text{ Btu/h} \cdot \text{ft}^2 \cdot \text{°F}$$

Based on guarded hot box tests of this wall without mortar joints, Tye and Spinney (1980) measured the average R-value for this insulated concrete block wall as 3.13°F·ft^2·h/Btu.

Assuming parallel heat flow only, the calculated resistance is higher than that calculated on the assumption of isothermal planes. The actual resistance generally is some value between the two calculated values. In the absence of test values, examination of the construction usually reveals whether a value closer to the higher or lower calculated R-value should be used. Generally, if the construction contains a layer in which lateral conduction is high compared with transmittance through the construction, the calculation with isothermal planes should be used. If the construction has no layer of high lateral conductance, the parallel heat flow calculation should be used.

Hot box tests of insulated and uninsulated masonry walls constructed with block of conventional configuration show that thermal resistances calculated using the isothermal planes heat flow method agree well with measured values (Van Geem 1985, Valore 1980, Shu et al. 1979). Neglecting horizontal mortar joints in conventional block can result in thermal transmittance values up to 16% lower than actual, depending on the density and thermal properties of the masonry, and 1 to 6% lower, depending on the core insulation material (Van Geem 1985, McIntyre 1984). For aerated concrete block walls, other solid masonry, and multicore block walls with full mortar joints, neglecting mortar joints can cause errors in R-values up to 40% (Valore 1988). Horizontal mortar joints usually found in concrete block wall construction are neglected in Example 2.

Constructions Containing Metal

Curtain and metal stud-wall constructions often include metallic and other thermal bridges, which can significantly reduce the thermal resistance. However, the capacity of the adjacent facing materials to transmit heat transversely to the metal is limited, and some contact resistance between all materials in contact limits the reduction. Contact resistances in building structures are only 0.06 to 0.6°F·ft^2·h/Btu—too small to be of concern in many cases. However, the contact resistances of steel framing members may be important. Also, in many cases (as illustrated in Example 3), the area of metal in contact with the facing greatly exceeds the thickness of the metal, which mitigates the contact reistance effects.

Thermal characteristics for panels of sandwich construction can be computed by combining the thermal resistances of the various layers. However, few panels are true sandwich constructions; many have ribs and stiffeners that create complicated heat flow paths. R-values for the assembled sections should be determined on a representative sample by using a hot box method. If the sample is a wall section with air cavities on both sides of fibrous insulation, the sample must be of representative height since convective airflow can contribute significantly to heat flow through the test section. Computer modeling can also be useful, but all heat transfer mechanisms must be considered.

In Example 3, the metal member is only 0.020 in. thick, but it is in contact with adjacent facings over a 1.25 in.-wide area. The steel member is 3.50 in. deep, has a thermal resistance of approximately 0.011°F·ft^2·h/Btu, and is virtually isothermal. The calculation involves careful selection of the appropriate thickness for the steel member. If the member is assumed to be 0.020 in. thick, the fact that the flange transmits heat to the adjacent facing is ignored, and the heat flow through the steel is underestimated. If the member is assumed to be 1.25 in. thick, the heat flow through the steel is overestimated. In Example 3, the steel member behaves in much the same way as a rectangular member 1.25 in. thick and 3.50 in. deep with a thermal resistance of $(1.25/0.020) \times 0.011 = 0.69$°F·ft²·h/Btu does. The Building Research Association of New Zealand (BRANZ) commonly uses this approximation.

Example 3. Calculate the C-factor of the insulated steel frame wall shown in Figure 4. Assume that the steel member has an R-value of 0.69°F·ft²·h/Btu and that the framing behaves as though it occupies approximately 8% of the transmission area.

Solution. Obtain the R-values of the various building elements from Table 4.

Element	*R* (Insul.)	*R* (Framing)
1. 0.5-in. gypsum wallboard	0.45	0.45
2. 3.5-in. mineral fiber batt insulation	11	—
3. Steel framing member	—	0.69
4. 0.5-in. gypsum wallboard	0.45	0.45
	$R_1 = 11.90$	$R_2 = 1.59$

Therefore, $C_1 = 0.084$; $C_2 = 0.629$ Btu/h·ft²·°F.

If the steel framing (thermal bridging) is not considered, the C-factor of the wall is calculated using Equation (3) from Chapter 22 as follows:

$$C_{av} = C_1 = 1/R_1 = 0.084 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^\circ\text{F}$$

If the steel framing is accounted for using the parallel flow method, the C-factor of the wall is determined using Equation (5) from Chapter 22 as follows:

$$C_{av} = (0.92 \times 0.084) + (0.08 \times 0.629)$$
$$= 0.128 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^\circ\text{F}$$
$$R_{T(av)} = 7.81 {}^\circ\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$$

If the steel framing is included using the isothermal planes method, the C-factor of the wall is determined using Equations (2) and (3) from Chapter 22 as follows:

$$R_{T(av)} = 0.45 + 1/[(0.92/11.00) + (0.08/0.69)] + 0.45$$
$$= 5.91 {}^\circ\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$$
$$C_{av} = 0.169 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^\circ\text{F}$$

For this insulated steel frame wall, Farouk and Larson (1983) measured an average R-value of 6.61°F·ft²·h/Btu.

In ASHRAE/IESNA *Standard* 90.1-1989, one method given for determining the thermal resistance of wall assemblies containing metal framing involves using a parallel path correction factor F_c, which is listed in Table 8C-2 of the standard. For 2 by 4 steel framing, 16 in. OC, $F_c = 0.50$. Using the correction factor method, an R-value of 6.40°F·ft²·h/Btu [0.45 + 11(0.50) + 0.45] is obtained for the wall described in Example 3.

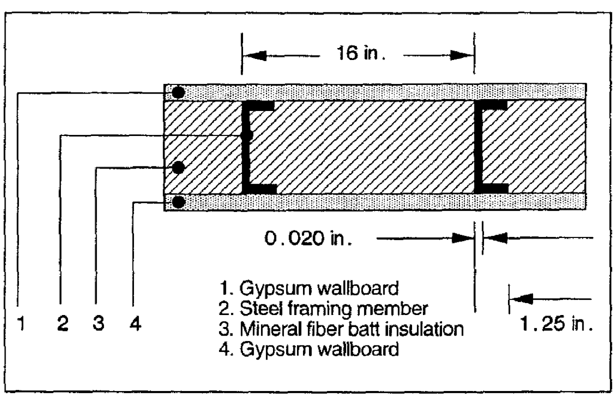


Fig. 4 Insulated Steel Frame Wall (Example 3)

Zone Method of Calculation

For structures with widely spaced metal members of substantial cross-sectional area, calculation by the isothermal planes method can result in thermal resistance values that are too low. For these constructions, the **zone method** can be used. This method involves two separate computations—one for a chosen limited portion, Zone A, containing the highly conductive element; the other for the remaining portion of simpler construction, Zone B. The two computations are then combined using the parallel flow method, and the average transmittance per unit overall area is calculated. The basic laws of heat transfer are applied by adding the area conductances *CA* of elements in parallel, and adding area resistances *R*/*A* of elements in series.

The surface shape of Zone A is determined by the metal element. For a metal beam (see Figure 5), the Zone A surface is a strip of width *W* that is centered on the beam. For a rod perpendicular to panel surfaces, it is a circle of diameter *W*. The value of *W* is calculated from Equation (1), which is empirical. The value of *d* should not be less than 0.5 in. for still air.

$$W = m + 2d \tag{1}$$

where

m = width or diameter of metal heat path terminal, in.
d = distance from panel surface to metal, in.

Generally, the value of *W* should be calculated using Equation (1) for each end of the metal heat path; the larger value, within the limits of the basic area, should be used as illustrated in Example 4.

Example 4. Calculate transmittance of the roof deck shown in Figure 5. Tee-bars at 24 in. OC support glass fiber form boards, gypsum concrete, and built-up roofing. Conductivities of components are: steel, 314.4 Btu·in/h·ft²·°F; gypsum concrete, 1.66 Btu·in/h·ft²·°F; and glass fiber form board, 0.25 Btu·in/h·ft²·°F. Conductance of built-up roofing is 3.00 Btu/h·ft²·°F.

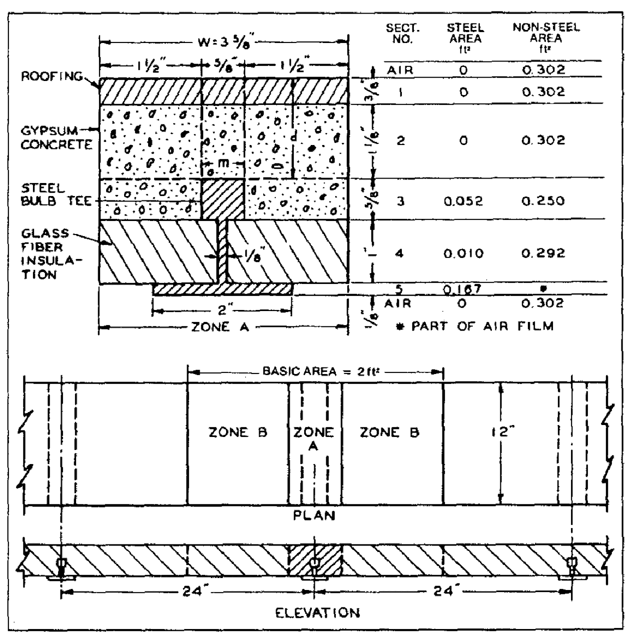


Fig. 5 Gypsum Roof Deck on Bulb Tees (Example 4)

Solution. The basic area is 2 ft^2 (24 in. by 12 in.) with a tee-bar (12 in. long) across the middle. This area is divided into Zones A and B.

Zone A is determined from Equation (1) as follows:

$$\text{Top side } W = m + 2d = 0.625 + (2 \times 1.5) = 3.625 \text{ in.}$$
$$\text{Bottom side } W = m + 2d = 2.0 + (2 \times 0.5) = 3.0 \text{ in.}$$

Using the larger value of W, the area of Zone A is $(12 \times 3.625)/144 = 0.302$ ft^2. The area of Zone B is $2.0 - 0.302 = 1.698$ ft^2.

To determine area transmittance for Zone A, divide the structure within the zone into five sections parallel to the top and bottom surfaces (Figure 5). The area conductance CA of each section is calculated by adding the area conductances of its metal and nonmetal paths. Area conductances of the sections are converted to area resistances R/A and added to obtain the total resistance of Zone A.

Section	Area × Conductance =	CA	$\frac{1}{CA} = \frac{R}{A}$
Air (outside, 15 mph)	0.302 × 6.00	1.81	0.55
No. 1, Roofing	0.302 × 3.00	0.906	1.10
No. 2, Gypsum concrete	0.302 × 1.66/1.125	0.446	2.24
No. 3, Steel	0.052 × 314.4/0.625	26.2	0.04
No. 3, Gypsum concrete	0.250 × 1.66/0.625	0.664	
No. 4, Steel	0.010 × 314.4/1.00	3.14	0.31
No. 4, Glass fiberboard	0.292 × 0.25/1.00	0.073	
No. 5, Steel	0.167 × 314.4/0.125	420.0	0.002
Air (inside)	0.302 × 1.63	0.492	2.03
		Total R/A =	6.27

Area transmittance of Zone A = $1/(R/A) = 1/6.27 = 0.159$.

For Zone B, the unit resistances are added and then converted to area transmittance, as shown in the following table.

Section	Resistance, R
Air (outside, 15 mph)	1/6.00 = 0.17
Roofing	1/3.00 = 0.33
Gypsum concrete	1.75/1.66 = 1.05
Glass fiberboard	1.00/0.25 = 4.00
Air (inside)	1/1.63 = 0.61
Total resistance	= 6.16

Since unit transmittance = $1/R = 0.162$, the total area transmittance UA is calculated as follows:

$$\begin{aligned} \text{Zone B} = 1.698 \times 0.162 &= 0.275 \\ \text{Zone A} &= \underline{0.159} \\ \text{Total area transmittance of basic area} &= 0.434 \\ \text{Transmittance per ft}^2 = 0.434/2.0 &= 0.217 \\ \text{Resistance per ft}^2 &= 4.61 \end{aligned}$$

Overall R-values of 4.57 and 4.85°F·ft^2·h/Btu have been measured in two guarded hot box tests of a similar construction.

When the steel member represents a relatively large proportion of the total heat flow path, as in Example 4, detailed calculations of resistance in sections 3, 4, and 5 of Zone A are unnecessary; if only the steel member is considered, the final result of Example 4 is the same. However, if the heat flow path represented by the steel member is small, as for a tie rod, detailed calculations for sections 3, 4, and 5 are necessary. A panel with an internal metallic structure and bonded on one or both sides to a metal skin or covering presents special problems of lateral heat flow not covered in the zone method.

Modified Zone Method for Metal Stud Walls with Insulated Cavities

The modified zone method is similar to the parallel path method and the zone method. All three methods are based on parallel-path calculations. Figure 6 shows the width w of the zone of thermal anomalies around a metal stud. This zone can be assumed to equal the length of the stud flange L (parallel path method), or can be calculated as a sum of the length of stud flange and a distance double that from wall surface to metal Σd_i (zone method). In the modified zone method the width of the zone depends on the following three parameters:

- Ratio between thermal resistivity of sheathing material and cavity insulation
- Size (depth) of stud
- Thickness of sheathing material

The Modified Zone Method is explained in Figure 6 (which can be copied and used as a calculation form). The wall cross section shown in Figure 6, is divided into two zones: the zone of thermal anomalies around metal stud w and the cavity zone cav. Wall material layers are grouped into an exterior and interior surface sections—A (sheathing, siding) and B (wallboard)—and interstitial sections I and II (cavity insulation, metal stud flange).

Assuming that the layers or layer of wall materials in wall section A are thicker than those in wall section B, as show by the cross section in Figure 6, they can be described as follows:

$$\sum_{i=1}^{n} d_i \geq \sum_{j=1}^{m} d_j \qquad (2)$$

where

n = number of material layer (of thickness d_i) between metal stud flange and wall surface for section A
m = number of material layer (of thickness d_j) for section B

Then, the width of the zone of thermal anomalies around the metal stud w can be estimated by

$$w = L + z_f \sum_{i=1}^{n} d_i \qquad (3)$$

where

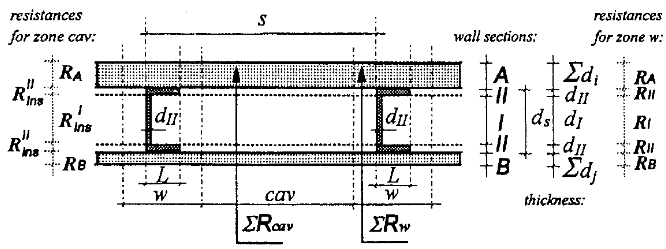
L = stud flange size,
d_i = thickness of material layer in section A
z_f = zone factor, which is shown in Figure 7 ($z_f = 2$ for zone method)

Kosny and Christian (1995) verified the accuracy of the Modified Zone Method for over 200 simulated cases of metal frame walls with insulated cavities. For all configurations considered the discrepancy between results were within ±2%. Hot box measured R-values for 15 metal stud walls tested by Barbour et al. (1994) were compared with results obtained by Kosny and Christian (1995) and McGowan and Desjarlais (1997). The Modified Zone Method was found to be the most accurate simple method for estimating the clear wall R-value of light-gage steel stud walls with insulated cavities. However, this analysis does not apply to construction with metal sheathing. Also, *ASHRAE Standard* 90.1 may require a different method of analysis.

Ceilings and Roofs

The overall R-value for ceilings of wood frame flat roofs can be calculated using Equations (1) through (5) from Chapter 22. Properties of the materials are found in Tables 1, 3, 2, and 4. The fraction of framing is assumed to be 0.10 for joists at 16 in. OC and 0.07 for joists at 24 in. OC. The calculation procedure is similar to that shown in Example 1. Note that if the ceiling contains plane air spaces (see Table 3), the resistance depends on the direction of heat flow, i.e., whether the calculation is for a winter (heat flow up) or summer (heat flow down) condition.

For ceilings of pitched roofs under winter conditions, calculate the R-value of the ceiling using the procedure for flat roofs. Table 5 can be used to determine the effective resistance of the



Wall Section	Material	Thick-ness, in.	Resistivity, h·ft²·°F/Btu·in
A		d_{i1} =	r_1 =
A		d_{i2} =	r_2 =
A		d_{i3} =	r_3 =
B		d_{j1} =	r_{j1} =
I & II	Metal	d_{II} =	r_{met}
I & II	Cavity insulation	d_s =	r_{ins}

s= .... ; $d_I = d_s - 2 \times d_{II}$ = ...

$$\frac{\text{resistivity of sheathing}}{\text{resistivity of cav. insul.}} = \ldots\ldots$$

Z_f (from Zone Factor Chart) = ...

$w = L + z_f \times \Sigma d_i$ = ...

$R_A = \Sigma(r_i \times d_i)$ = ...

$R_B = \Sigma(r_j \times d_j)$ = ...

$R^I_{ins} = r_{ins} \times d_I$ = ...

$R^{II}_{ins} = r_{ins} \times d_{II}$ = ...

$R^I_{met} = r_{met} \times d_I$ = ...

$R^{II}_{met} = r_{met} \times d_{II}$ = ...

$$R_I = \frac{R^I_{met} \times R^I_{ins} \times w}{d_{II} \times (R^I_{ins} - R^I_{met}) + w \times R^I_{met}} = \text{———} = \ldots\ldots$$

$$R_{II} = \frac{R^{II}_{met} \times R^{II}_{ins} \times w}{L \times (R^{II}_{ins} - R^{II}_{met}) + w \times R^{II}_{met}} = \text{———} = \ldots\ldots$$

$$\Sigma R_{cav} = R_A + R_B + R^I_{ins} + 2 \times R^{II}_{ins} = \ldots\ldots$$

$$\Sigma R_w = R_A + R_B + R_I + 2 \times R_{II} = \ldots\ldots$$

$$R_{tot} = \frac{\Sigma R_w \times \Sigma R_{cav} \times s}{w \times (\Sigma R_{cav} - \Sigma R_w) + s \times \Sigma R_w} = \text{———} =$$

Fig. 6 Modified Zone Method R-Value Calculation Form for Metal Stud Walls

attic space under summer conditions for varying conditions of ventilation air temperature, airflow direction and rates, ceiling resistance, roof or sol-air temperatures, and surface emittances (Joy 1958).

The R-value is the total resistance obtained by adding the ceiling and effective attic resistances. The applicable temperature difference is that difference between room air and sol-air temperatures or between room air and roof temperatures (see Table 5, footnote f). Table 5 can be used for pitched and flat residential roofs over attic spaces. When an attic has a floor, the ceiling resistance should account for the complete ceiling-floor construction.

Windows and Doors

Table 5 of Chapter 29 lists U-factors for various fenestration products. Table 6 in Chapter 29 lists U-factors for exterior wood and steel doors. All U-factors are approximate, because a significant portion of the resistance of a window or door is contained in the air film resistances, and some parameters that may have important effects are not considered. For example, the listed U-factors assume the surface temperatures of surrounding bodies are equal to the ambient air temperature. However, the indoor surface of a window or door in an actual installation may be exposed to nearby radiating surfaces, such as radiant heating panels, or opposite walls with much higher or lower temperatures than the indoor air. Air movement across the indoor surface of a window or door, such as that caused by nearby heating and cooling outlet grilles, increases the U-factor; and air movement (wind) across the outdoor surface of a window or door also increases the U-factor.

U_o Concept

U_o is the combined thermal transmittance of the respective areas of gross exterior wall, roof or ceiling or both, and floor assemblies. The U_o equation for a wall is as follows:

$$U_o = (U_{wall}A_{wall} + U_{window}A_{window} + U_{door}A_{door})/A_o \quad (4)$$

where

U_o = average thermal transmittance of gross wall area
A_o = gross area of exterior walls
U_{wall} = thermal transmittance of all elements of opaque wall area
A_{wall} = opaque wall area
U_{window} = thermal transmittance of window area (including frame)
A_{window} = window area (including frame)
U_{door} = thermal transmittance of door area
A_{door} = door area (including frame)

Where more than one type of wall, window, or door is used, the UA term for that exposure should be expanded into its subelements, as shown in Equation (3).

$$\begin{aligned} U_oA_o = {} & U_{wall\ 1}A_{wall\ 1} + U_{wall\ 2}A_{wall\ 2} + \ldots + U_{wall\ m}A_{wall\ m} \\ & + U_{window\ 1}A_{window\ 1} + U_{window\ 2}A_{window\ 2} + \ldots \\ & + U_{window\ n}A_{window\ n} + U_{door\ 1}A_{door\ 1} \\ & + U_{door\ 2}A_{door\ 2} + \ldots + U_{door\ o}A_{door\ o} \end{aligned} \quad (5)$$

Table 5 Effective Thermal Resistance of Ventilated Attics[a] (Summer Condition)

NONREFLECTIVE SURFACES											
		No Ventilation[b]		Natural Ventilation		Power Ventilation[c]					
		Ventilation Rate, cfm/ft²									
		0		0.1[d]		0.5		1.0		1.5	
		Ceiling Resistance R^e, °F·ft²·/Btu									
Ventilation Air Temperature, °F	Sol-Air[f] Temperature, °F	10	20	10	20	10	20	10	20	10	20
80	120	1.9	1.9	2.8	3.4	6.3	9.3	9.6	16	11	20
	140	1.9	1.9	2.8	3.5	6.5	10	9.8	17	12	21
	160	1.9	1.9	2.8	3.6	6.7	11	10	18	13	22
90	120	1.9	1.9	2.5	2.8	4.6	6.7	6.1	10	6.9	13
	140	1.9	1.9	2.6	3.1	5.2	7.9	7.6	12	8.6	15
	160	1.9	1.9	2.7	3.4	5.8	9.0	8.5	14	10	17
100	120	1.9	1.9	2.2	2.3	3.3	4.4	4.0	6.0	4.1	6.9
	140	1.9	1.9	2.4	2.7	4.2	6.1	5.8	8.7	6.5	10
	160	1.9	1.9	2.6	3.2	5.0	7.6	7.2	11	8.3	13
REFLECTIVE SURFACES[g]											
80	120	6.5	6.5	8.1	8.8	13	17	17	25	19	30
	140	6.5	6.5	8.2	9.0	14	18	18	26	20	31
	160	6.5	6.5	8.3	9.2	15	18	19	27	21	32
90	120	6.5	6.5	7.5	8.0	10	13	12	17	13	19
	140	6.5	6.5	7.7	8.3	12	15	14	20	16	22
	160	6.5	6.5	7.9	8.6	13	16	16	22	18	25
100	120	6.5	6.5	7.0	7.4	8.0	10	8.5	12	8.8	12
	140	6.5	6.5	7.3	7.8	10	12	11	15	12	16
	160	6.5	6.5	7.6	8.2	11	14	13	18	15	20

[a]Although the term *effective resistance* is commonly used when there is attic ventilation, this table includes values for situations with no ventilation. The effective resistance of the attic added to the resistance ($1/U$) of the ceiling yields the effective resistance of this combination based on sol-air (see Chapter 28) and room temperatures. These values apply to wood frame construction with a roof deck and roofing that has a conductance of 1.0 Btu/h·ft²·°F.

[b]This condition cannot be achieved in the field unless extreme measures are taken to tightly seal the attic.

[c]Based on air discharging outward from attic.

[d]When attic ventilation meets the requirements stated in Chapter 25, 0.1 cfm/ft² is assumed as the natural summer ventilation rate.

[e]When determining ceiling resistance, do not add the effect of a reflective surface facing the attic, as it is accounted for in the Reflective Surfaces part of the table.

[f]Roof surface temperature rather than sol-air temperature (see Chapter 28) can be used if 0.25 is subtracted from the attic resistance shown.

[g]Surfaces with effective emittance ε_{eff} = 0.05 between ceiling joists facing attic space.

Table 6 Transmission Coefficients U for Wood and Steel Doors, Btu/h·ft²·°F

Nominal Door Thickness, in.	Description	No Storm Door	Wood Storm Door[c]	Metal Storm Door[d]
Wood Doors[a,b]				
1-3/8	Panel door with 7/16-in. panels[e]	0.57	0.33	0.37
1-3/8	Hollow core flush door	0.47	0.30	0.32
1-3/8	Solid core flush door	0.39	0.26	0.28
1-3/4	Panel door with 7/16-in. panels[e]	0.54	0.32	0.36
1-3/4	Hollow core flush door	0.46	0.29	0.32
1-3/4	Panel door with 1-1/8-in. panels[e]	0.39	0.26	0.28
1-3/4	Solid core flush door	0.40	—	0.26
2-1/4	Solid core flush door	0.27	0.20	0.21
Steel Doors[b]				
1-3/4	Fiberglass or mineral wool core with steel stiffeners, no thermal break[f]	0.60	—	—
1-3/4	Paper honeycomb core without thermal break[f]	0.56	—	—
1-3/4	Solid urethane foam core without thermal break[a]	0.40	—	—
1-3/4	Solid fire rated mineral fiberboard core without thermal break[f]	0.38	—	—
1-3/4	Polystyrene core without thermal break (18 gage commercial steel)[f]	0.35	—	—
1-3/4	Polyurethane core without thermal break (18 gage commercial steel)[f]	0.29	—	—
1-3/4	Polyurethane core without thermal break (24 gage residential steel)[f]	0.29	—	—
1-3/4	Polyurethane core with thermal break and wood perimeter (24 gage residential steel)[f]	0.20	—	—
1-3/4	Solid urethane foam core with thermal break[a]	0.20	—	0.16

Note: All U-factors for exterior doors in this table are for doors with no glazing, except for the storm doors which are in addition to the main exterior door. Any glazing area in exterior doors should be included with the appropriate glass type and analyzed as a window (see Chapter 29). Interpolation and moderate extrapolation are permitted for door thicknesses other than those specified.

[a]Values are based on a nominal 32 in. by 80 in. door size with no glazing.

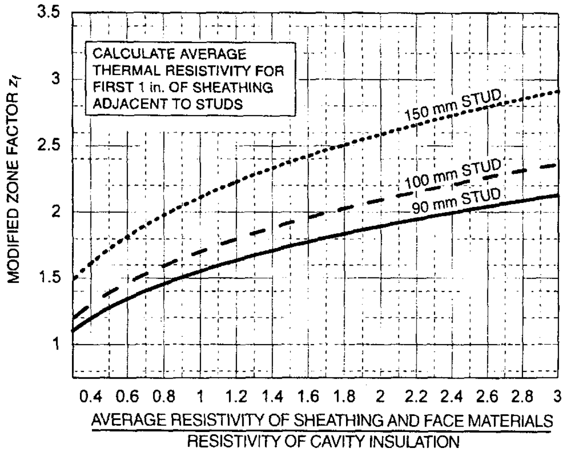
[b]Outside air conditions: 15 mph wind speed, 0°F air temperature; inside air conditions: natural convection, 70°F air temperature.

[c]Values for wood storm door are for approximately 50% glass area.

[d]Values for metal storm door are for any percent glass area.

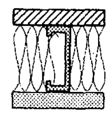
[e]55% panel area.

[f]ASTM C 236 hotbox data on a nominal 3 ft by 7 ft door size with no glazing.



Use $z_f = -0.5$ for walls when total thickness of layer of materials attached to one side of metal frame ≤ **5/8 in. and** thermal resistivity of sheathing ≤ **1.5 h·ft²·°F/Btu·in.**

Use $z_f = +0.5$ for walls when total thickness of layer of materials attached to one side of metal frame ≤ **5/8 in. and** thermal resistivity of sheathing > **1.5 h·ft²·°F/Btu·in**



Find z_f in chart above for walls when total thickness of layer of materials attached to one side of metal frame > **5/8 in.**

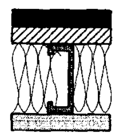


Fig. 7 Modified Zone Factor for Calculating R-Value of Metal Stud Walls with Cavity Insulation

Example 5. Calculate U_o for a wall 30 ft by 8 ft, constructed as in Example 1. The wall contains two double-glazed (0.5 in. airspace) fixed windows with wood/vinyl frames. (From Table 5 in Chapter 29, U = 0.52 Btu/h·ft²·°F.) One window is 60 in. by 34 in. and the second 36 in. by 30 in. The wall also contains a 1.75-in. solid core flush door with a metal storm door 34 in. by 80 in. (U = 0.26 Btu/h·ft²·°F from Table 6).

Solution. The U-factor for the wall was obtained in Example 1. The areas of the different components are:

$$A_{window} = [(60\times 34)+(36\times 30)]/144 = 21.7\ \mathrm{ft}^2$$

$$A_{door} = (34\times 80)/144 = 18.9\ \mathrm{ft}^2$$

$$A_{wall} = (30\times 8)-(21.7+18.9) = 199.4\ \mathrm{ft}^2$$

Therefore, the combined thermal transmittance for the wall is:

$$U_o = \frac{(0.063\times 199.4)+(0.52\times 21.7)+(0.26\times 18.9)}{(30\times 8)}$$

$$= 0.119\ \mathrm{Btu/h\cdot ft^2\cdot °F}$$

Slab-on-Grade and Below-Grade Construction

Heat transfer through basement walls and floors to the ground depends on the following factors: (1) the difference between the air temperature within the room and that of the ground and outside air, (2) the material of the walls or floor, and (3) the thermal conductivity of the surrounding earth. The latter varies with local conditions and is usually unknown. Because of the great thermal inertia of the surrounding soil, ground temperature varies with depth, and there is a substantial time lag between changes in outdoor air temperatures and corresponding changes in ground temperatures. As a result, ground-coupled heat transfer is less amenable to steady-state representation than above-grade building elements. However, several simplified procedures for estimating ground-coupled heat transfer have been developed. These fall into two principal categories: (1) those that reduce the ground heat transfer problem to a closed form solution, and (2) those that use simple regression equations developed from statistically reduced multidimensional transient analyses.

Closed form solutions, including the ASHRAE arc-length procedure discussed in Chapter 27 by Latta and Boileau (1969), generally reduce the problem to one-dimensional, steady-state heat transfer. These procedures use simple, "effective" U-factors or ground temperatures or both. Methods differ in the various parameters averaged or manipulated to obtain these effective values. Closed form solutions provide acceptable results in climates that have a single dominant season, because the dominant season persists long enough to permit a reasonable approximation of steady-state conditions at shallow depths. The large errors (percentage) that are likely during transition seasons should not seriously affect building design decisions, since these heat flows are relatively insignificant when compared with those of the principal season.

The ASHRAE arc-length procedure is a reliable method for wall heat losses in cold winter climates. Chapter 27 discusses a slab-on-grade floor model developed by one study. Although both procedures give results comparable to transient computer solutions for cold climates, their results for warmer U.S. climates differ substantially.

Research conducted by Hougten et al. (1942) and Dill et al. (1945) indicates a heat flow of approximately 2.0 Btu/h·ft² through an uninsulated concrete basement floor with a temperature difference of 20°F between the basement floor and the air 6 in. above it. A U-factor of 0.10 Btu/h·ft²·°F is sometimes used for concrete basement floors on the ground. For basement walls below grade, the temperature difference for winter design conditions is greater than for the floor. Test results indicate that at the midheight of the below-grade portion of the basement wall, the unit area heat loss is approximately twice that of the floor.

For concrete slab floors in contact with the ground at grade level, tests indicate that for small floor areas (equal to that of a 25 ft by 25 ft house) the heat loss can be calculated as proportional to the length of exposed edge rather than total area. This amounts to 0.81 Btu/h per linear foot of exposed edge per degree Fahrenheit difference between the indoor air temperature and the average outdoor air temperature. This value can be reduced appreciably by installing insulation under the ground slab and along the edge between the floor and abutting walls. In most calculations, if the perimeter loss is calculated accurately, no other floor losses need to be considered. Chapter 27 contains data for load calculations and heat loss values for below-grade walls and floors at different depths.

The second category of simplified procedures uses transient two-dimensional computer models to generate the ground heat transfer data that are then reduced to compact form by regression analysis (see Mitalas 1982 and 1983, Shipp 1983). These are the most accurate procedures available, but the database is very expensive to generate. In addition, these methods are limited to the range of climates and constructions specifically examined. Extrapolating beyond the outer bounds of the regression surfaces can produce significant errors.

Apparent Thermal Conductivity of Soil

Effective or apparent soil thermal conductivity is difficult to estimate precisely and may change substantially in the same soil at different times due to changed moisture conditions and the presence of

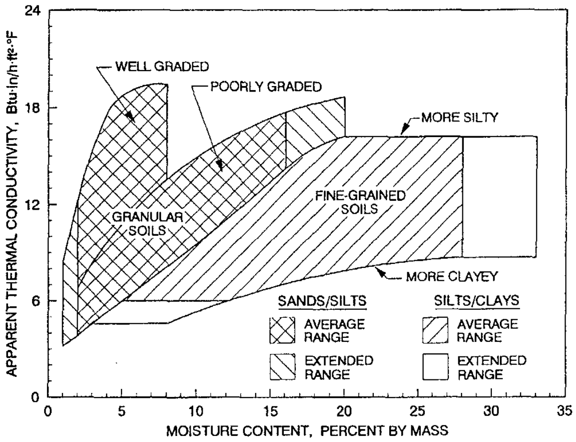


Fig. 8 Trends of Apparent Thermal Conductivity of Moist Soils

freezing temperatures in the soil. Figure 8 shows the typical apparent soil thermal conductivity as a function of moisture content for different general types of soil. The figure is based on data presented in Salomone and Marlowe (1989) using envelopes of thermal behavior coupled with field moisture content ranges for different soil types. In Figure 8, the term well-graded applies to granular soils with good representation of all particle sizes from largest to smallest. The term poorly graded refers to granular soils with either a uniform gradation, in which most particles are about the same size, or a skip (or gap) gradation, in which particles of one or more intermediate sizes are not present.

Although thermal conductivity varies greatly over the complete range of possible moisture contents for a soil, this range can be narrowed if it is assumed that the moisture contents of most field soils lie between the "wilting point" of the soil (i.e., the moisture content of a soil below which a plant cannot alleviate its wilting symptoms) and the "field capacity" of the soil (i.e., the moisture content of a soil that has been thoroughly wetted and then drained until the drainage rate has become negligibly small). After a prolonged dry spell, the moisture will be near the wilting point, and after a rainy period, the soil will have a moisture content near its field capacity. The moisture contents at these limits have been studied by many agricultural researchers, and data for different types of soil are given by Salomone and Marlowe (1989) and Kersten (1949). The shaded areas on Figure 8 approximate (1) the full range of moisture contents for different soil types and (2) a range between average values of each limit.

Table 7 gives a summary of design values for thermal conductivities of the basic soil classes. Table 8 gives ranges of thermal conductivity for some basic classes of rock. The value chosen depends on whether heat transfer is being calculated for minimum heat loss through the soil, as in a ground heat exchange system, or a maximum value, as in peak winter heat loss calculations for a basement. Hence, a high and a low value are given for each soil class.

As heat flows through the soil, the moisture tends to move away from the source of heat. This moisture migration provides initial mass transport of heat, but it also dries the soil adjacent to the heat source, hence lowering the apparent thermal conductivity in that zone of soil.

Trends typical in a soil when other factors are held constant are:

- k increases with moisture content
- k increases with increasing dry density of a soil
- k decreases with increasing organic content of a soil

Table 7 Typical Apparent Thermal Conductivity Values for Soils, Btu·in/h·ft²·°F

		Recommended Values for Design[a]	
	Normal Range	Low[b]	High[c]
Sands	4.2 to 17.4	5.4	15.6
Silts	6 to 17.4	11.4	15.6
Clays	6 to 11.4	7.8	10.8
Loams	6 to 17.4	6.6	15.6

[a]Reasonable values for use when no site- or soil-specific data are available.
[b]Moderately conservative values for minimum heat loss through soil (e.g., use in soil heat exchanger or earth-contact cooling calculations). Values are from Salomone and Marlowe (1989).
[c]Moderately conservative values for maximum heat loss through soil (e.g., use in peak winter heat loss calculations). Values are from Salomone and Marlowe (1989).

Table 8 Typical Apparent Thermal Conductivity Values for Rocks, Btu·in/h·ft²·°F

	Normal Range
Pumice, tuff, obsidian	3.6 to 15.6
Basalt	3.6 to 18.0
Shale	6 to 27.6
Granite	12 to 30
Limestone, dolomite, marble	8.4 to 30
Quartzose sandstone	9.6 to 54

- k tends to decrease for soils with uniform gradations and rounded soil grains (because the grain-to-grain contacts are reduced)
- k of a frozen soil may be higher or lower than that of the same unfrozen soil (because the conductivity of ice is higher than that of water but lower than that of the typical soil grains). Differences in k below moisture contents of 7 to 8% are quite small. At approximately 15% moisture content, differences in k-factors may vary up to 30% from unfrozen values.

When calculating annual energy use, values that represent typical site conditions as they vary during the year should be chosen. In climates where ground freezing is significant, accurate heat transfer simulations should include the effect of the latent heat of fusion of water. The energy released during this phase change significantly retards the progress of the frost front in moist soils.

Water Vapor Transmission Data for Building Components

Table 9 gives typical water vapor permeance and permeability values for common building materials. These values can be used to calculate water vapor flow through building components and assemblies using equations in Chapter 22.

MECHANICAL AND INDUSTRIAL SYSTEMS

Thermal Transmission Data

Table 10 lists the thermal conductivities of various materials used as industrial insulations. These values are functions of the arithmetic mean of the temperatures of the inner and outer surfaces for each insulation.

Heat Loss from Pipes and Flat Surfaces

Tables 11A, 11B, and 12 give heat losses from bare steel pipes and flat surfaces and bare copper tubes. These tables were calculated using ASTM *Standard* C 680. User inputs for the programs described in the standard include operating temperature, ambient temperature, pipe size, insulation type, number of insulation layers, and thickness for each layer. A program option allows the user to input a surface coefficient or surface emittance, surface orientation, and wind speed. The computer uses this information to calculate the

Table 9 Typical Water Vapor Permeance and Permeability Values for Common Building Materials[a]

Material	Thickness, in.	Permeance, Perm	Resistance[h], Rep	Permeability, Perm-in.	Resistance/in.[h], Rep/in.
Construction Materials					
Concrete (1:2:4 mix)				3.2	0.31
Brick masonry	4	0.8[f]	1.3		
Concrete block (cored, limestone aggregate)	8	2.4[f]	0.4		
Tile masonry, glazed	4	0.12[f]	8.3		
Asbestos cement board	0.12	4-8[d]	0.1-0.2		
With oil-base finishes		0.3-0.5[d]	2-3		
Plaster on metal lath	0.75	15[f]	0.067		
Plaster on wood lath		11[e]	0.091		
Plaster on plain gypsum lath (with studs)		20[f]	0.050		
Gypsum wall board (plain)	0.375	50[f]	0.020		
Gypsum sheathing (asphalt impregnated)	0.5			20[d]	0.050
Structural insulating board (sheathing quality)				20-50[f]	0.050-0.020
Structural insulating board (interior, uncoated)	0.5	50-90[f]	0.020-0.011		
Hardboard (standard)	0.125	11[f]	0.091		
Hardboard (tempered)	0.125	5[f]	0.2		
Built-up roofing (hot mopped)		0			
Wood, sugar pine				0.4-5.4[b]	2.5-0.19
Plywood (douglas fir, exterior glue)	0.25	0.7[f]	1.4		
Plywood (douglas fir, interior glue)	0.25	1.9[f]	0.53		
Acrylic, glass fiber reinforced sheet	0.056	0.12[d]	8.3		
Polyester, glass fiber reinforced sheet	0.048	0.05[d]	20		
Thermal Insulations					
Air (still)				120[f]	0.0083
Cellular glass				0[d]	∞
Corkboard				2.1-2.6[d]	0.48-0.38
				9.5[e]	0.11
Mineral wool (unprotected)				116[e]	0.0086
Expanded polyurethane (R-11 blown) board stock				0.4-1.6[d]	2.5-0.62
Expanded polystyrene—extruded				1.2[d]	0.83
Expanded polystyrene—bead				2.0-5.8[d]	0.50-0.17
Phenolic foam (covering removed)				26	0.038
Unicellular synthetic flexible rubber foam				0.02-0.15[d]	50-6.7
Plastic and Metal Foils and Films[c]					
Aluminum foil	0.001	0.0[d]	∞		
Aluminum foil	0.00035	0.05[d]	20		
Polyethylene	0.002	0.16[d]	6.3		3100
Polyethylene	0.004	0.08[d]	12.5		3100
Polyethylene	0.006	0.06[d]	17		3100
Polyethylene	0.008	0.04[d]	25		3100
Polyethylene	0.010	0.03[d]	33		3100
Polyvinylchloride, unplasticized	0.002	0.68[d]	1.5		
Polyvinylchloride, plasticized	0.004	0.8-1.4[d]	1.3-0.72		
Polyester	0.001	0.73[d]	1.4		
Polyester	0.0032	0.23[d]	4.3		
Polyester	0.0076	0.08[d]	12.5		
Cellulose acetate	0.01	4.6[d]	0.2		
Cellulose acetate	0.125	0.32[d]	3.1		

heat flow and the surface temperature. The programs calculate the surface coefficients if the user has not already supplied them.

The equations used in ASTM C 680 are:

$$h_{cv} = C\left(\frac{1}{d}\right)^{0.2}\left(\frac{1}{T_{avg}}\right)^{0.181}(\Delta T^{0.266})\sqrt{1 + 1.277(\text{Wind})} \quad (6)$$

where

h_{cv} = convection surface coefficient, Btu/h·ft²·°F
d = diameter for cylinder, in. For flat surfaces and large cylinders ($d > 24$ in.), use $d = 24$ in.
T_{avg} = average temperature of air film = $(T_a + T_s)/2$, °R
T_a = temperature of ambient air, °R
T_s = temperature of surface, °R
ΔT = surface to air temperature difference, °R
Wind = air speed, mph
C = constant depending on shape and heat flow condition
= 1.016 for horizontal cylinders
= 1.235 for longer vertical cylinders
= 1.394 for vertical plates
= 1.79 for horizontal plates, warmer than air, facing upward
= 0.89 for horizontal plates, warmer than air, facing downward
= 0.89 for horizontal plates, cooler than air, facing upward
= 1.79 for horizontal plates, cooler than air, facing downward

Table 9 Typical Water Vapor Permeance and Permeability Values for Common Building Materials (*Concluded*)[a]

Material	Weight, lb/100 ft²	Permeance, Perms			Resistance[h] Rep		
		Dry-Cup	Wet-Cup	Other	Dry-Cup	Wet-Cup	Other
Building Paper, Felts, Roofing Papers[g]							
Duplex sheet, asphalt laminated, aluminum foil one side	8.6	0.002	0.176		500	5.8	
Saturated and coated roll roofing	65	0.05	0.24		20	4.2	
Kraft paper and asphalt laminated, reinforced 30-120-30	6.8	0.3	1.8		3.3	0.55	
Blanket thermal insulation backup paper, asphalt coated	6.2	0.4	0.6-4.2		2.5	1.7-0.24	
Asphalt-saturated and coated vapor retarder paper	8.6	0.2-0.3	0.6		5.0-3.3	1.7	
Asphalt-saturated, but not coated, sheathing paper	4.4	3.3	20.2		0.3	0.05	
15-lb asphalt felt	14	1.0	5.6		1.0	0.18	
15-lb tar felt	14	4.0	18.2		0.25	0.055	
Single-kraft, double	3.2	31	42		0.032	0.024	
Liquid-Applied Coating Materials	**Thickness, in.**						
Commercial latex paints (dry film thickness)[i]							
Vapor retarder paint	0.0031			0.45			2.22
Primer-sealer	0.0012			6.28			0.16
Vinyl acetate/acrylic primer	0.002			7.42			0.13
Vinyl-acrylic primer	0.0016			8.62			0.12
Semi-gloss vinyl-acrylic enamel	0.0024			6.61			0.15
Exterior acrylic house and trim	0.0017			5.47			0.18
Paint-2 coats							
Asphalt paint on plywood			0.4			2.5	
Aluminum varnish on wood		0.3-0.5			3.3-2.0		
Enamels on smooth plaster				0.5-1.5			2.0-0.66
Primers and sealers on interior insulation board				0.9-2.1			1.1-0.48
Various primers plus 1 coat flat oil paint on plaster				1.6-3.0			0.63-0.33
Flat paint on interior insulation board				4			0.25
Water emulsion on interior insulation board				30-85			0.03-0.012
	Weight, oz/ft²						
Paint-3 coats							
Exterior paint, white lead and oil on wood siding		0.3-1.0			3.3-1.0		
Exterior paint, white lead-zinc oxide and oil on wood		0.9			1.1		
Styrene-butadiene latex coating	2	11			0.09		
Polyvinyl acetate latex coating	4	5.5			0.18		
Chlorosulfonated polyethylene mastic	3.5	1.7			0.59		
	7.0	0.06			16		
Asphalt cutback mastic, 1/16 in., dry		0.14			7.2		
3/16 in., dry		0.0			—		
Hot melt asphalt	2	0.5			2		
	3.5	0.1			10		

[a]This table permits comparisons of materials; but in the selection of vapor retarder materials, exact values for permeance or permeability should be obtained from the manufacturer or from laboratory tests. The values shown indicate variations among mean values for materials that are similar but of different density, orientation, lot, or source. The values should not be used as design or specification data. Values from dry-cup and wet-cup methods were usually obtained from investigations using ASTM E 96 and C 355; values shown under others were obtained by two-temperature, special cell, and air velocity methods. Permeance, resistance, permeability, and resistance per unit thickness values are given in the following units:

Permeance	Perm	= gr/h·ft²·in. Hg
Resistance	Rep	= in. Hg·ft²·h/gr
Permeability	Perm-in.	= gr/h·ft²·(in. Hg/in.)
Resistance/unit thickness	Rep/in.	= (in. Hg·ft²·h/gr)/in.

[h]Depending on construction and direction of vapor flow.

[c]Usually installed as vapor retarders, although sometimes used as an exterior finish and elsewhere near the cold side, where special considerations are then required for warm side barrier effectiveness.

[d]Dry-cup method.

[e]Wet-cup method.

[f]Other than dry- or wet-cup method.

[g]Low permeance sheets used as vapor retarders. High permeance used elsewhere in construction.

[h]Resistance and resistance/in. values have been calculated as the reciprocal of the permeance and permeability values.

[i]Cast at 10 mils (0.01 in.) wet film thickness.

$$h_{rad} = \frac{\varepsilon\sigma(T_a^{\,4} - T_s^{\,4})}{T_a - T_s} \qquad (7)$$

where

h_{rad} = radiation surface coefficient, Btu/h·ft²·°F
ε = surface emittance
σ = Stefan-Boltzmann constant = 0.1713×10^{-8} Btu/h·ft²·°R⁴

Example 6. Compute the total annual heat loss from 165 ft of nominal 2-in. bare steel pipe in service 4000 h per year. The pipe is carrying steam at 10 psig and is exposed to an average air temperature of 80°F.

Solution. The pipe temperature is taken as the steam temperature, which is 239.4°F, obtained by interpolation from Steam Tables. By interpolation in Table 11A between 180°F and 280°F, heat loss from a nominal 2-in. pipe is 285 Btu/h·ft. Total annual heat loss from the entire line is 285 Btu/h·ft × 165 ft × 4000 h = 188×10^6 Btu.

In calculating heat flow, Equations (9) and (10) from Chapter 22 generally are used. For dimensions of standard pipe and fitting sizes, refer to the *Piping Handbook*. For insulation product dimensions, refer to ASTM *Standard* C 585, or to the insulation manufacturers' literature.

Examples 7 and 8 illustrate how Equations (9) and (10) from Chapter 22 can be used to determine heat loss from both flat and

Table 10 Typical Thermal Conductivity for Industrial Insulations at Various Mean Temperatures—Design Values[a]

Material	Max. Temp.,[b] °F	Typical Density, lb/ft³	Typical Conductivity in Btu·in/h·ft²·°F at Mean Temp., °F: −100	−75	−50	−25	0	25	50	75	100	200	300	500	700	900
BLANKETS AND FELTS																
ALUMINOSILICATE FIBER																
7 to 10 μm diameter fiber	1800	4								0.24		0.32		0.54	0.99	1.03
	2000	6-8								0.25		0.30		0.48	0.78	0.95
3 μm diameter fiber	2200	4								0.22		0.29		0.45	0.59	0.74
MINERAL FIBER (Rock, slag, or glass)																
Blanket, metal reinforced	1200	6-12									0.26	0.32	0.39	0.54		
	1000	2.5-6									0.24	0.31	0.40	0.61		
Blanket, flexible, fine-fiber organic bonded	350	0.75				0.25	0.26	0.28	0.30	0.33	0.36	0.53				
		0.75				0.24	0.25	0.27	0.29	0.32	0.34	0.48				
		1.0				0.23	0.24	0.25	0.27	0.29	0.32	0.43				
		1.5				0.21	0.22	0.23	0.25	0.27	0.28	0.37				
		2.0				0.20	0.21	0.22	0.23	0.25	0.26	0.33				
		3.0				0.19	0.20	0.21	0.22	0.23	0.24	0.31				
Blanket, flexible, textile fiber, organic bonded	350	0.65				0.27	0.28	0.29	0.30	0.31	0.32	0.50	0.68			
		0.75				0.26	0.27	0.28	0.29	0.31	0.32	0.48	0.66			
		1.0				0.24	0.25	0.26	0.27	0.29	0.31	0.45	0.60			
		1.5				0.22	0.23	0.24	0.25	0.27	0.29	0.39	0.51			
		3.0				0.20	0.21	0.22	0.23	0.24	0.25	0.32	0.41			
Felt, semirigid organic bonded	400	3-8						0.24	0.25	0.26	0.27	0.35	0.44			
Laminated and felted without binder	850	3	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.35	0.55			
	1200	7.5											0.35	0.45	0.60	
BLOCKS, BOARDS, AND PIPE INSULATION																
MAGNESIA	600	11-12									0.35	0.38	0.42			
85% CALCIUM SILICATE	1200	11-15									0.38	0.41	0.44	0.52	0.62	0.72
	1800	12-15												0.63	0.74	0.95
CELLULAR GLASS	900	7.8-8.2	0.24	0.25	0.26	0.28	0.29	0.30	0.32	0.33	0.34	0.41	0.49	0.70	1.01	
DIATOMACEOUS SILICA	1600	21-22												0.64	0.68	0.72
	1900	23-25												0.70	0.75	0.80
MINERAL FIBER (Glass)																
Organic bonded, block and boards	400	3-10	0.16	0.17	0.18	0.19	0.20	0.22	0.24	0.25	0.26	0.33	0.40			
Nonpunking binder	1000	3-10									0.26	0.31	0.38	0.52		
Pipe insulation, slag, or glass	350	3-4					0.20	0.21	0.22	0.23	0.24	0.29				
	500	3-10					0.20	0.22	0.24	0.25	0.26	0.33	0.40			
Inorganic bonded block	1000	10-15									0.33	0.38	0.45	0.55		
	1800	15-24									0.32	0.37	0.42	0.52	0.62	0.74
Pipe insulation, slag, or glass	1000	10-15									0.33	0.38	0.45	0.55		
Resin binder		15	0.23	0.24	0.25	0.26	0.28	0.29								
RIGID POLYSTYRENE																
Extruded (CFC-12 exp.)(smooth skin surface)	165	1.8-3.5	0.16	0.16	0.17	0.16	0.17	0.18	0.19	0.20						
Molded beads	165	1	0.17	0.19	0.20	0.21	0.22	0.24	0.25	0.26	0.28					
		1.25	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.27					
		1.5	0.16	0.17	0.19	0.20	0.21	0.22	0.23	0.24	0.26					
		1.75	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25					
		2.0	0.15	0.16	0.18	0.19	0.20	0.21	0.22	0.23	0.24					
RIGID POLYURETHANE/POLYISOCYANURATE[c,d]																
Unfaced (CFC-11 exp.)	210	1.5-2.5	0.16	0.17	0.18	0.18	0.18	0.17	0.16	0.16	0.17					
RIGID POLYISOCYANURATE																
Gas-impermeable facers (CFC-11 exp.)	250	2.0						0.12	0.13	0.14	0.15					
RIGID PHENOLIC																
Closed cell (CFC-11, CFC-113 exp.)		3.0						0.11	0.115	0.12	0.125					
RUBBER, Rigid foamed	150	4.5						0.20	0.21	0.22	0.23					
VEGETABLE AND ANIMAL FIBER																
Wool felt (pipe insulation)	180	20						0.28	0.30	0.31	0.33					
INSULATING CEMENTS																
MINERAL FIBER (Rock, slag, or glass)																
With colloidal clay binder	1800	24-30									0.49	0.55	0.61	0.73	0.85	
With hydraulic setting binder	1200	30-40									0.75	0.80	0.85	0.95		
LOOSE FILL																
Cellulose insulation (milled pulverized paper or wood pulp)		2.5-3							0.26	0.27	0.29					
Mineral fiber, slag, rock, or glass		2-5			0.19	0.21	0.23	0.25	0.26	0.28	0.31					
Perlite (expanded)		3-5	0.22	0.24	0.25	0.27	0.28	0.30	0.31	0.33	0.35					
Silica aerogel		7.6			0.13	0.14	0.15	0.15	0.16	0.17	0.18					
Vermiculite (expanded)		7-8.2			0.39	0.40	0.42	0.44	0.45	0.47	0.49					
		4-6			0.34	0.35	0.38	0.40	0.42	0.44	0.46					

[a]Representative values for dry materials, which are intended as design (not specification) values for materials in normal use. Insulation materials in actual service may have thermal values that vary from design values depending on their in-situ properties (e.g., density and moisture content). For properties of a particular product, use the value supplied by the manufacturer or by unbiased tests.

[b]These temperatures are generally accepted as maximum. When operating temperature approaches these limits, follow the manufacturers' recommendations.

[c]Some polyurethane foams are formed by means that produce a stable product (with respect to k), but most are blown with refrigerant and will change with time.

[d]See Table 4, footnote i.

[e]See Table 4, footnote j.

Table 11A Heat Loss from Bare Steel Pipe to Still Air at 80°F[a], Btu/h·ft

Nominal Pipe Size[b], in.	Pipe Inside Temperature, °F									
	180	280	380	480	580	680	780	880	980	1080
0.50	59.3	147.2	263.2	412.3	600.9	836.8	1128.6	1485.6	1918.0	2436.8
0.75	72.5	180.1	322.6	506.2	739.2	1031.2	1392.9	1836.0	2373.5	3018.8
1.00	88.8	220.8	396.1	622.7	910.9	1272.6	1721.2	2271.5	2939.4	3741.6
1.25	109.7	272.8	490.4	772.3	1131.7	1583.8	2145.6	2835.4	3673.4	4680.9
1.50	123.9	308.5	555.1	875.1	1283.8	1798.3	2438.2	3224.6	4180.5	5330.0
2.00	151.8	378.1	681.4	1076.3	1581.5	2218.9	3012.6	3989.2	5177.2	6606.8
2.50	180.5	450.0	811.9	1284.0	1888.8	2652.6	3604.3	4775.3	6199.5	7912.5
3.00	215.9	538.8	973.5	1541.8	2271.4	3194.0	4344.9	5762.2	7486.9	9562.3
3.50	243.9	609.0	1101.4	1746.1	2574.7	3623.6	4933.0	6546.4	8510.4	10874.3
4.00	271.6	678.6	1228.2	1948.7	2875.9	4050.5	5517.5	7326.0	9528.1	12178.9
4.50	299.2	747.7	1354.4	2150.9	3176.8	4477.7	6103.8	8109.5	10553.2	13496.2
5.00	329.8	824.7	1494.8	2375.4	3510.6	4950.7	6751.3	8972.5	11678.4	14936.3
6.00	387.1	968.7	1757.8	2796.8	4138.0	5841.4	7972.7	10603.1	13808.2	17667.6
7.00	440.5	1102.8	2003.0	3189.9	4723.9	6673.5	9114.2	12127.4	15799.4	20220.8
8.00	493.3	1235.7	2246.1	3580.0	5305.5	7500.0	10248.4	13642.2	17778.2	22758.0
9.00	545.9	1368.1	2488.8	3970.2	5888.7	8331.0	11392.1	15174.5	19787.1	25343.6
10.00	604.3	1514.8	2757.2	4400.7	6530.1	9241.1	12638.6	16835.1	21949.2	28104.9
11.00	656.0	1644.8	2995.5	4783.8	7102.1	10054.9	13756.2	18328.4	23900.3	30606.1
12.00	704.0	1762.3	3203.8	5104.9	7557.3	10661.8	14524.9	19256.7	24967.6	31766.8
14.00	771.0	1934.2	3525.9	5636.0	8373.9	11862.4	16235.5	21635.6	28212.3	36120.3
16.00	872.2	2189.0	3993.2	6387.4	9495.9	13458.0	18424.8	24556.6	32021.1	40990.7
18.00	972.5	2441.7	4456.7	7132.9	10609.4	15041.3	20596.7	27453.2	35795.6	45813.1
20.00	1072.1	2692.4	4916.8	7873.2	11715.1	16613.4	22752.5	30326.8	39537.6	50590.0
24.00	1269.3	3188.9	5828.3	9339.9	13905.5	19726.9	27019.7	36010.1	46930.3	60014.7

Table 11B Heat Loss from Flat Surfaces to Still Air at 80°F, Btu/h·ft²

	Surface Inside Temperature, °F									
	180	280	380	480	580	680	780	880	980	1080
Vertical surface	212.2	533.1	973.3	1558.6	2321.2	3298.0	4530.1	6062.8	7945.5	10231.5
Horizontal surface										
Facing up	234.7	586.4	1061.1	1683.5	2484.9	3501.9	4775.4	6350.4	8276.3	10606.1
Facing down	183.6	465.3	861.4	1399.6	2112.8	3038.4	4217.8	5696.7	7524.5	9754.7

[a]Calculations from ASTM C 680; steel: k = 314.4 Btu·in/h·ft²·°F; ε = 0.94.

[b]Losses per square foot of pipe for pipes larger than 24 in. can be considered the same as losses per square foot for 24-in. pipe.

cylindrical surfaces. Figure 9 shows surface resistance as a function of heat transmission for both flat and cylindrical surfaces. The surface emittance is assumed to be 0.85 to 0.90 in still air at 80°F.

Example 7. Compute the heat loss from a boiler wall if the interior insulation surface temperature is 1100°F and ambient still air temperature is 80°F. The wall is insulated with 4.5 in. of mineral fiber block and 0.5 in. of mineral fiber insulating and finishing cement.

Solution. Assume that the mean temperature of the mineral fiber block is 700°F, the mean temperature of the insulating cement is 200°F, and the surface resistance R_s is 0.60 ft²·°F·h/Btu.

From Table 10, k_1 = 0.62 and k_2 = 0.80. Using Equation (9) from Chapter 22:

$$q_s = \frac{1100 - 80}{(4.5/0.62) + (0.5/0.80) + 0.60} = 120.2 \text{ Btu/h} \cdot \text{ft}^2$$

As a check, from Figure 9, at 120.2 Btu/h·ft², R_s = 0.56. The mean temperature of the mineral fiber block is:

$$4.5/0.62 = 7.26;\ 7.26/2 = 3.63$$

$$1100 - \frac{3.63}{8.48}(1020) = 663°\text{F}$$

and the mean temperature of the insulating cement is:

$$0.5/0.80 = 0.63;\ 0.63/2 = 0.31;\ 7.26 + 0.31 = 7.57$$

$$1100 - \frac{7.57}{8.48}(1020) = 189°\text{F}$$

From Table 10, at 663°F, k_1 = 0.60; at 189°F, k_2 = 0.79.

Using these adjusted values to recalculate q_s:

$$q_s = \frac{1020}{(4.5/0.60) + (0.5/0.79) + 0.56} = \frac{1020}{8.69}$$

$$= 117.4 \text{ Btu/h} \cdot \text{ft}^2$$

From Figure 9, at 117.4 Btu/h·ft², R_s = 0.56. The mean temperature of the mineral fiber block is:

$$4.5/0.6 = 7.50;\ 7.50/2 = 3.75$$

$$1100 - \frac{3.75}{8.69}(1020) = 660°\text{F}$$

and the mean temperature of the insulating cement is:

$$0.5/0.79 = 0.63;\ 0.63/2 = 0.31;\ 7.50 + 0.31 = 7.81$$

$$1100 - \frac{7.81}{8.69}(1020) = 183°\text{F}$$

From Table 10, at 660°F, k_1 = 0.60; at 183°F, k_2 = 0.79.

Since R_s, k_1, and k_2 do not change at these values, q_s = 117.4 Btu/h·ft.

Example 8. Compute heat loss per square foot of outer surface of insulation if pipe temperature is 1200°F and ambient still air temperature is 80°F. The pipe is nominal 6-in. steel pipe, insulated with a nominal 3-in. thick diatomaceous silica as the inner layer and a nominal 2-in. thick calcium silicate as the outer layer.

Table 12 Heat Loss from Bare Copper Tube to Still Air at 80°F[a], Btu/h·ft

Nominal Tube Size, in.	Tube Inside Temperature, °F								
	120	150	180	210	240	270	300	330	
0.250	7.1	14.1	21.9	30.6	39.9	49.9	60.6	71.9	
0.375	9.1	18.0	28.1	39.1	51.1	63.9	77.6	92.2	
0.500	11.0	21.8	34.0	47.4	61.9	77.5	94.1	111.8	
0.750	14.7	29.1	45.4	63.3	82.7	103.6	126.0	149.8	
1.000	18.3	36.2	56.4	78.7	102.8	128.9	156.7	186.5	
1.250	21.8	43.1	67.2	93.6	122.4	153.4	186.7	222.2	
1.500	25.2	49.8	77.6	108.3	141.5	177.4	216.0	257.1	
2.000	31.8	62.9	98.0	136.7	178.8	224.3	273.1	325.4	
2.500	38.3	75.6	117.9	164.4	215.1	269.8	328.7	391.8	Dull ε = 0.44
3.000	44.6	88.1	137.2	191.5	250.5	314.4	383.2	456.9	
3.500	50.8	100.3	156.3	218.0	285.4	358.2	436.7	520.8	
4.000	57.0	112.3	175.0	244.2	319.7	401.4	489.4	583.9	
5.000	69.0	135.9	211.7	295.5	386.9	486.0	592.8	707.6	
6.000	80.7	159.0	247.7	345.7	452.8	568.9	694.2	829.0	
8.000	103.7	204.1	317.8	443.7	581.3	730.7	892.1	1066.0	
10.000	126.1	247.9	386.1	539.1	706.5	888.4	1085.2	1297.4	
12.000	148.0	290.9	453.0	632.5	829.2	1043.1	1274.6	1524.4	
0.250	5.4	10.8	16.9	23.5	30.5	37.9	45.5	53.5	
0.375	6.8	13.7	21.4	29.7	38.6	47.9	57.6	67.6	
0.500	8.2	16.4	25.7	35.7	46.3	57.4	69.1	81.2	
0.750	10.7	21.6	33.8	46.9	60.9	75.6	90.9	106.8	
1.000	13.2	26.5	41.4	57.6	74.7	92.8	111.6	131.2	
1.250	15.5	31.3	48.8	67.8	88.0	109.3	131.6	154.7	
1.500	17.8	35.8	56.0	77.8	100.9	125.3	150.8	177.4	
2.000	22.2	44.6	69.7	96.8	125.7	156.1	187.9	221.1	Bright ε = 0.08
2.500	26.4	53.0	82.8	115.1	149.5	185.6	223.5	263.0	
3.000	30.5	61.2	95.6	132.8	172.4	214.2	257.9	303.5	
3.500	34.4	69.1	107.9	150.0	194.8	242.0	291.4	342.9	
4.000	38.3	76.8	120.0	166.8	216.6	269.1	324.1	381.4	
5.000	45.7	91.8	143.4	199.3	258.8	321.6	387.4	456.1	
6.000	53.0	106.3	166.0	230.7	299.7	372.5	448.7	528.3	
8.000	66.8	134.1	209.4	291.1	378.2	470.1	566.5	667.2	
10.000	80.2	160.8	251.0	349.0	453.4	563.7	679.5	800.4	
12.000	93.0	186.5	291.3	404.9	526.1	654.2	788.7	929.3	

[a]Calculations from ASTM C 680; for copper: $k = 2784$ Btu·in/h·ft²·°F.

Solution. From Chapter 40 of the 1996 *ASHRAE Handbook—Equipment*, $r_o = 3.31$ in. A nominal 3-in. thick diatomaceous silica insulation to fit a nominal 6-in. steel pipe is 3.02 in. thick. A nominal 2-in. thick calcium silicate insulation to fit over the 3.02-in. diatomaceous silica is 2.08 in. thick. Therefore, $r_i = 6.33$ in. and $r_s = 8.41$ in..

Assume that the mean temperature of the diatomaceous silica is 600°F, the mean temperature of the calcium silicate is 250°F and the surface resistance R_s is 0.50. From Table 10, $k_1 = 0.66$; $k_2 = 0.42$. By Equation (10) from Chapter 22:

$$q_s = \frac{1200 - 80}{[8.41\ln(6.33/3.31)/0.66] + [8.41\ln(8.41/3.31)/0.40] + 0.50}$$

$$= \frac{1120}{(5.45/0.66) + (2.39/0.40) + 0.50} = 76.0\ \text{Btu/h}\cdot\text{ft}^2$$

From Figure 9, at 76.0 Btu/h·ft², $R_s = 0.60$. The mean temperature of the diatomaceous silica is:

$$5.45/0.66 = 8.26;\ 8.26/2 = 4.13$$

$$1200 - \frac{4.13}{14.83}(1120) = 888°\text{F}$$

and the mean temperature of the calcium silicate is:

$$2.39/0.40 = 5.98;\ 5.98/2 = 2.99;\ 8.26 + 2.99 = 11.25$$

$$1200 - \frac{11.25}{14.83}(1120) = 350°\text{F}$$

From Table 10, $k_1 = 0.72$; $k_2 = 0.46$. Recalculating:

$$q_s = \frac{1120}{(5.45/0.72) + (2.39/0.46) + 0.60} = 83.8\ \text{Btu/h}\cdot\text{ft}^2$$

From Figure 9 at 83.8 Btu/h·ft², $R_s = 0.59$. The mean temperature of the diatomaceous silica is:

$$5.45/0.72 = 7.57;\ 7.57/2 = 3.78$$

$$1200 - \frac{3.78}{13.36}(1120) = 883°\text{F}$$

and the mean temperature of the calcium silicate is:

$$2.39/0.40 = 5.98;\ 5.98/2 = 2.99;\ 8.26 + 2.99 = 11.25$$

$$1200 - \frac{11.25}{14.83}(1120) = 350°\text{F}$$

From Table 10, $k_1 = 0.72$; $k_2 = 0.46$. Recalculating:

$$2.39/0.46 = 5.20;\ 5.20/2 = 2.60;\ 7.57 + 2.60 = 10.17$$

$$1200 - \frac{10.17}{13.36}(1120) = 347°\text{F}$$

Since R_s, k_1, and k_2 do not change at 83.8 Btu/h·ft², this is q_s. The heat flow per ft² of the inner surface of the insulation is:

$$q_o = q_s(r_s/r_o) = 83.8(8.41/3.31) = 213\ \text{Btu/h}\cdot\text{ft}^2$$

Table 13 Recommended Thicknesses for Pipe and Equipment Insulation

Nom Dia., in.		MINERAL FIBER (Fiberglass and Rock Wool)										CALCIUM		
		Process Temperature, °F										Process Temp., °F		
		150	250	350	450	550	650	750	850	950	1050	150	250	350
	Thickness	1	1½	2	2½	3	3½	4	4	4½	5½	1	1½	2
½	Heat loss	8	16	24	33	43	54	66	84	100	114	13	24	34
	Surface temp.	72	75	76	78	79	81	82	86	87	87	75	78	80
	Thickness	1	1½	2	2½	3½	4	4	4½	5	5½	1	2	2½
1	Heat loss	11	21	30	41	49	61	79	96	114	135	16	26	38
	Surface temp.	73	76	78	80	79	81	84	86	88	89	76	76	79
	Thickness	1	2	2½	3	4	4	4	5½	5½	6	1½	2½	3
1½	Heat loss	14	22	33	45	54	73	94	103	128	152	17	29	42
	Surface temp.	73	74	77	79	79	82	86	84	88	90	73	75	78
	Thickness	1½	2	3	3½	4	4	4	5½	6	6	1½	2½	3
2	Heat loss	13	25	34	47	61	81	105	114	137	168	19	32	47
	Surface temp.	71	75	75	77	79	83	87	85	87	91	74	76	79
	Thickness	1½	2½	3½	4	4	4½	4½	6	6½	7	2	3	3½
3	Heat loss	16	28	39	54	75	94	122	133	154	184	21	37	54
	Surface temp.	72	74	75	77	81	83	87	86	87	90	73	75	78
	Thickness	1½	3	4	4	4	5	5½	6	7	7½	2	3	4
4	Heat loss	19	29	42	63	88	102	126	152	174	206	25	43	58
	Surface temp.	72	73	74	78	82	86	85	87	88	90	70	76	77
	Thickness	2	3	4	4	4½	5	5½	6½	7½	8	2	3½	4
6	Heat loss	21	38	54	81	104	130	159	181	208	246	33	51	75
	Surface temp.	71	74	75	79	82	84	87	88	89	91	74	75	79
	Thickness	2	3½	4	4	5	5	5½	7	8	8½	2½	3½	4
8	Heat loss	26	42	65	97	116	155	189	204	234	277	35	62	90
	Surface temp.	71	73	76	80	81	86	89	88	89	92	73	76	79
	Thickness	2	3½	4	4	5	5½	5½	7½	8½	9	2½	4	4
10	Heat loss	32	50	77	115	136	170	220	226	259	307	41	66	106
	Surface temp.	72	74	77	81	82	85	90	87	89	91	73	75	80
	Thickness	2	3½	4	4	5	5½	5½	7½	8½	9½	2½	4	4
12	Heat loss	36	57	87	131	154	192	249	253	290	331	47	75	121
	Surface temp.	72	74	77	82	82	86	91	88	89	91	73	76	81
	Thickness	2	3½	4	4	5	5½	6½	7½	9	9½	2½	4	4
14	Heat loss	40	61	94	141	165	206	236	271	297	352	51	81	130
	Surface temp.	72	74	77	82	83	86	87	89	89	91	73	76	81
	Thickness	2½	3½	4	4	5½	5½	7	8	9	10	3	4	4
16	Heat loss	37	68	105	157	171	228	247	284	326	372	50	90	144
	Surface temp.	71	74	78	83	82	87	86	88	89	91	72	76	82
	Thickness	2½	3½	4	4	5½	5½	7	8	9	10	3	4	4
18	Heat loss	41	75	115	173	187	250	270	310	354	404	55	99	159
	Surface temp.	71	74	78	83	83	87	87	88	90	91	73	76	82
	Thickness	2½	3½	4	4	5½	5½	7	8	9	10	3	4	4
20	Heat loss	45	82	126	189	204	272	292	335	383	436	60	108	174
	Surface temp.	71	75	78	83	83	87	87	89	90	92	73	77	82
	Thickness	2½	4	4	4	5½	6	7½	8	9	10	3	4	4
24	Heat loss	53	86	147	221	237	295	320	386	439	498	71	127	203
	Surface temp.	71	74	78	83	83	86	86	89	91	93	73	77	82
	Thickness	2½	4	4	4	5½	6½	7½	8½	10	10	3	4	4
30	Heat loss	65	105	179	268	286	332	383	439	481	591	86	154	247
	Surface temp.	71	74	79	84	84	85	87	89	89	94	73	77	83
	Thickness	2½	4	4	4	5½	7	8	9	10	10	2½	4	4
36	Heat loss	77	123	211	316	335	364	422	486	556	683	119	181	291
	Surface temp.	71	74	79	84	84	84	86	88	90	94	74	77	83
	Thickness	2	3½	4	4½	5½	8½	9½	10	10	10	2½	3½	4
Flat	Heat loss	10	14	20	27	31	27	31	38	47	58	12	20	28
	Surface temp.	72	74	77	80	82	80	82	85	89	93	73	77	81

Consult manufacturer's literature for product temperature limitations. Table is based on typical operating conditions, e.g., 65 °F ambient temperature and 7.5 mph wind speed, and may not represent actual conditions of use. Units for thickness, heat loss, and surface temperature are in inches, Btu/h·ft (Btu/h·ft^2 for flat surfaces), and °F, respectively.

Table 13 Recommended Thicknesses for Pipe and Equipment Insulation (*Concluded*)

Nom. Dia., in.		SILICATE							CELLULAR GLASS						
		Process Temperature, °F							Process Temperature, °F						
		450	550	650	750	850	950	1050	150	250	350	450	550	650	750
	Thickness	2½	3	3½	4	4	4	4	1½	1½	2	2½	3	3½	4
½	Heat loss	42	53	63	75	90	108	128	9	23	34	48	62	78	92
	Surface temp.	81	82	83	84	87	91	94	70	76	78	82	83	85	84
	Thickness	3	3½	4	4	4	4	4	1½	2	2½	3	3½	4	4
1	Heat loss	49	60	72	89	109	130	154	12	25	38	52	68	86	112
	Surface temp.	80	82	83	86	90	94	98	71	75	77	79	81	83	88
	Thickness	3½	4	4	4	4	5	5	1½	2½	3	4	4	4	4
1½	Heat loss	54	68	86	106	128	139	164	15	28	44	56	79	105	137
	Surface temp.	80	81	85	88	92	91	94	72	75	77	78	82	87	92
	Thickness	3½	4	4½	5	5½	6	6	1½	2½	3	4	4	4	4½
2	Heat loss	61	75	90	106	123	142	167	17	31	47	61	84	113	140
	Surface temp.	81	82	84	85	87	88	91	72	74	77	78	82	86	89
	Thickness	4	4½	5	5½	6	6	6	1½	3	3½	4	4	4½	5
3	Heat loss	71	87	105	123	143	71	202	22	35	54	75	105	132	161
	Surface temp.	80	82	84	85	87	90	94	73	74	77	79	84	86	89
	Thickness	4	4½	5	5½	6	6½	7	2	3	4	4	4	4½	5
4	Heat loss	82	101	121	142	164	187	213	22	41	59	87	122	150	185
	Surface temp.	81	83	85	87	89	90	92	71	74	76	80	85	87	90
	Thickness	4	4½	5	5½	6	7	8	2	3½	4	4	4½	5½	6
6	Heat loss	105	129	153	178	205	224	245	30	48	74	111	144	171	212
	Surface temp.	83	85	87	89	91	91	91	72	74	77	82	85	86	89
	Thickness	4½	5	5	6	7	8	8½	2½	3½	4	4	5	5½	6½
8	Heat loss	117	144	183	200	220	243	277	30	58	90	134	161	203	238
	Surface temp.	82	85	89	89	89	90	92	71	74	78	83	84	87	89
	Thickness	4	5	5½	6	7½	8½	9	2½	4	4	4	5½	5½	7
10	Heat loss	149	168	200	233	243	269	306	37	63	106	159	178	238	264
	Surface temp.	85	86	88	90	89	89	91	71	74	79	84	84	87	88
	Thickness	4	5	5½	7	8	8½	9½	2½	4	4	4	5½	5½	7½
12	Heat loss	170	191	266	236	262	300	330	42	71	121	181	201	269	284
	Surface temp.	86	86	89	88	88	90	91	71	74	79	85	84	90	88
	Thickness	4	5	5½	7	8	9	9½	2½	4	4	4	5½	5½	8
14	Heat loss	183	205	242	252	262	308	352	47	79	134	199	219	293	293
	Surface temp.	86	87	89	88	88	89	91	72	74	80	85	85	91	87
	Thickness	4	5½	6½	7½	8	9	10	2½	4	4	4	5½	5½	8
16	Heat loss	204	211	237	265	307	338	372	53	88	149	222	242	325	322
	Surface temp.	87	85	86	87	89	90	91	72	75	80	86	86	91	88
	Thickness	4	5½	6½	7½	8½	9	10	2½	4	4	4	5½	5½	8
18	Heat loss	225	232	259	289	320	367	403	59	96	164	245	266	356	351
	Surface temp.	87	86	87	87	88	90	91	72	75	80	86	86	92	88
	Thickness	4	5½	6½	7½	8½	9½	10	2½	4	4	4½	5½	5½	8
20	Heat loss	245	252	281	312	346	381	435	64	105	179	243	289	387	379
	Surface temp.	87	86	87	88	89	90	92	72	75	81	84	86	92	88
	Thickness	4	5½	6½	7½	8½	9½	10	2½	4	4	5	5½	5½	8
24	Heat loss	287	293	325	360	397	437	497	76	123	209	260	336	449	436
	Surface temp.	88	87	88	88	89	90	93	72	75	81	83	87	93	89
	Thickness	4	5½	7	8	9	10	10	2½	4	4	5½	5½	5½	8
30	Heat loss	349	353	368	409	452	498	589	93	150	254	290	405	542	521
	Surface temp.	88	87	87	88	89	90	94	72	75	81	82	87	93	90
	Thickness	4	6½	7½	8	9	10	10	2½	4	4	5½	5½	5½	8
36	Heat loss	410	359	406	475	524	576	681	110	176	229	340	474	635	606
	Surface temp.	89	84	86	88	89	91	94	73	76	81	82	88	94	90
	Thickness	5½	6½	7½	8½	9½	10	10	2½	4	4	5½	5½	7½	8½
Flat	Heat loss	29	33	36	39	43	49	58	11	17	29	31	44	43	50
	Surface temp.	81	83	84	85	87	89	93	73	76	83	84	90	90	93

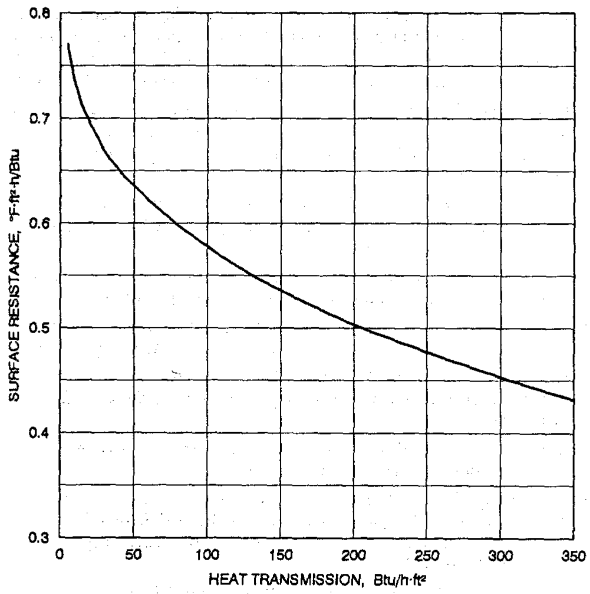


Fig. 9 Surface Resistance as Function of Heat Transmission for Flat Surfaces and Cylindrical Surfaces Greater than 24 in. in Diameter

Because trial and error techniques are tedious, the computer programs previously described should be used to estimate heat flows per unit area of flat surfaces or per unit length of piping, and interface temperatures including surface temperatures.

Several methods can be used to determine the most effective thickness of insulation for piping and equipment. Table 13 shows the recommended insulation thicknesses for three different pipe and equipment insulations. Installed cost data can be developed using procedures described by the Federal Energy Administration (1976). Computer programs capable of calculating thickness information are available from several sources. Also, manufacturers of insulations offer computerized analysis programs for designers and owners to evaluate insulation requirements. For more information on determining economic insulation thickness, see Chapter 22.

Chapters 3 and 22 give guidance concerning process control, personnel protection, condensation control, and economics. For specific information on sizes of commercially available pipe insulation, see ASTM *Standard* C 585 and consult with the North American Insulation Manufacturers Association (NAIMA) and its member companies.

CALCULATING HEAT FLOW FOR BURIED PIPELINES

In calculating heat flow to or from buried pipelines, the thermal properties of the soil must be assumed. Table 7 gives the apparent thermal conductivity values of various soil types, and Figure 8 shows the typical trends of apparent soil thermal conductivity with moisture content for various soil types. Table 8 provides ranges of apparent thermal conductivity for various types of rock. Kernsten (1949) also discusses thermal properties of soils. Carslaw and Jaeger (1959) give methods for calculating the heat flow taking place between one or more buried cylinders and the surroundings.

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Table B-2–Framed Wall Assembly U-Factors

Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-factor	Metal Wall U-factor
2x4 @ 16" O.C.	11 (Compressed)	0	0.098	0.202
		4	0.068	0.112
		5	0.064	0.101
		7	0.056	0.084
		8.7	0.051	0.073
	13	0	0.088	0.195
		4	0.063	0.109
		5	0.059	0.099
		7	0.052	0.082
		8.7	0.048	0.072
	15	0	0.081	0.189
		4	0.059	0.108
		5	0.055	0.097
		7	0.049	0.077
		8.7	0.045	0.071
2x4 @ 24" O.C.	11	0	0.094	0.173
		4	0.066	0.102
		5	0.062	0.093
		7	0.055	0.078
		8.7	0.050	0.069
	13	0	0.085	0.165
		4	0.061	0.099
		5	0.057	0.090
		7	0.051	0.077
		8.7	0.047	0.068
	15	0	0.077	0.158
		4	0.056	0.097
		5	0.053	0.088
		7	0.047	0.071
		8.7	0.044	0.067

Table B-3–Framed Wall Assembly U-Factors (Continued)

Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-factor	Metal Wall U-factor
2x6 @ 16" O.C.	19 (Compressed)	0	0.065	0.120
		4	0.058	0.098
		5	0.048	0.089
		7	0.043	0.075
		8.7	0.040	0.067
	21	0	0.059	0.157
		4	0.046	0.096
		5	0.044	0.088
		7	0.041	0.075
		8.7	0.037	0.066
	22 (Compressed)	0	0.062	0.158
		4	0.048	0.097
		5	0.045	0.088
		7	0.041	0.075
		8.7	0.038	0.067
2x6 @ 24" O.C.	19 (Compressed)	0	0.062	0.135
		4	0.048	0.088
		5	0.045	0.081
		7	0.042	0.070
		8.7	0.039	0.062
	21	0	0.056	0.130
		4	0.044	0.086
		5	0.042	0.079
		7	0.039	0.068
		8.7	0.036	0.061
	22 (Compressed)	0	0.058	0.132
		4	0.046	0.086
		5	0.043	0.079
		7	0.040	0.068
		8.7	0.037	0.061

Table B-2–Framed Wall Assembly U-Factors

Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-factor	Metal Wall U-factor
2x8 @ 16" O.C.	19	0	0.059	0.145
		4	0.047	0.092
		5	0.044	0.084
		7	0.041	0.072
		8.7	0.038	0.064
	22	0	0.054	0.140
		4	0.043	0.090
		5	0.041	0.082
		7	0.038	0.071
		8.7	0.035	0.063
	25	0	0.050	0.136
		4	0.040	0.088
		5	0.038	0.081
		7	0.035	0.070
		8.7	0.033	0.062
	30 (Compressed)	0	0.048	0.135
		4	0.039	0.088
		5	0.037	0.081
		7	0.035	0.070
		8.7	0.032	0.062
2x8 @ 24" O.C.	19	0	0.056	0.122
		4	0.045	0.082
		5	0.043	0.076
		7	0.040	0.066
		8.7	0.037	0.059
	22	0	0.051	0.117
		4	0.041	0.080
		5	0.040	0.074
		7	0.036	0.064
		8.7	0.034	0.058
	25	0	0.047	0.113
		4	0.038	0.078
		5	0.037	0.072
		7	0.034	0.063
		8.7	0.032	0.057
	30 (Compressed)	0	0.046	0.112
		4	0.037	0.077
		5	0.036	0.072
		7	0.034	0.063
		8.7	0.031	0.057

Table B-3–Framed Wall Assembly U-Factors (Continued)

Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-factor	Metal Wall U-factor
2x10 @ 16" O.C.	30	0	0.041	0.120
		4	0.035	0.081
		5	0.033	0.075
		7	0.031	0.065
		8.7	0.029	0.059
	38 (Compressed)	0	0.040	0.119
		4	0.033	0.080
		5	0.032	0.074
		7	0.030	0.065
		8.7	0.028	0.058
2x10 @ 24" O.C.	30 (Compressed)	0	0.039	0.099
		4	0.033	0.071
		5	0.032	0.066
		7	0.030	0.058
		8.7	0.028	0.053
	38	0	0.038	0.097
		4	0.032	0.070
		5	0.031	0.066
		7	0.029	0.058
		8.7	0.027	0.053

Table B-2A–Solar Heat Gain Coefficients Used for Exterior Shading[1]

Exterior Shading Device	***SHGC***
Standard Bug Screens	0.76
Exterior Sunscreens with weave 53*16/inch	0.30
Louvered Sunscreens with louvers as wide as openings	0.27
Low Sun Angle (LSA) Louvered Sunscreens	0.13
Roll-down Awning	0.13
Roll Down Blinds or Slats	0.13
None (for skylights only)	1.00

1 Exterior operable awnings (canvas, plastic or metal), except those that roll vertically down and cover the entire window, should be treated as overhangs for purposes of compliance with the Standards.

Table B-3–Metal Framing Factor

METAL FRAMING FACTORS			
Stud Spacing	Stud Depth	Insulation R-Value	Framing Factor
16" o.c.	4"	R-7	0.522
		R-11	0.403
		R-13	0.362
		R-15	0.328
	6"	R-19	0.325
		R-21	0.300
		R-22	0.287
		R-25	0.263
24" o.c.	4"	R-7	0.577
		R-11	0.458
		R-13	0.415
		R-15	0.379
	6"	R-19	0.375
		R-21	0.348
		R-22	0.335
		R-25	0.308
R-value calculation for Exterior Wall Assemblies with Metal Studs, July, 19, 1990, Staff Draft Docket 90-CON-1.			
*Correction to metal framing factors applies to the entire assembly including: interior air films, interior surfaces, cavity/insulation, exterior surfaces, and exterior air films.			

Table B-4–Properties of Hollow Unit Masonry Walls

Type			Core Treatment		
			Solid	Partly Grouted with Ungrouted Cells	
			Grout	Empty	Insulated
12"	LW CMU	U	0.51	0.43	0.30
		Rw	2.0	2.3	3.3
		HC	23	14.8	14.8
	MW CMU	U	0.54	0.46	0.33
		Rw	1.9	2.2	3.0
		HC	23.9	15.6	15.6
	NW CMU	U	0.57	0.49	0.36
		Rw	1.8	2.0	2.8
		HC	24.8	16.5	16.5
10"	LW CMU	U	0.55	0.46	0.34
		Rw	1.8	2.2	2.9
		HC	18.9	12.6	12.6
	MW CMU	U	0.59	0.49	0.37
		Rw	1.7	2.1	2.7
		HC	19.7	13.4	13.4
	NW CMU	U	0.62	0.52	0.41
		Rw	1.6	1.9	2.4
		HC	20.5	14.2	14.2
8"	LW CMU	U	0.62	0.50	0.37
		Rw	1.6	2.0	2.7
		HC	15.1	9.9	9.9
	MW CMU	U	0.65	0.53	0.41
		Rw	1.5	1.9	2.4
		HC	15.7	10.5	10.5
	NW CMU	U	0.69	0.56	0.44
		Rw	1.4	1.8	2.3
		HC	16.3	11.1	11.1
	Clay Unit	U	0.57	0.47	0.39
		Rw	1.8	2.1	2.6
		HC	15.1	11.4	11.4
6"	LW CMU	U	0.68	0.54	0.44
		Rw	1.5	1.9	2.3
		HC	10.9	7.9	7.9
	MW CMU	U	0.72	0.58	0.48
		Rw	1.4	1.7	2.1
		HC	11.4	8.4	8.4
	NW CMU	U	0.76	0.61	0.52
		Rw	1.3	1.6	1.9
		HC	11.9	8.9	8.9
	Clay Unit	U	0.65	0.52	0.45
		Rw	1.5	1.9	2.2
		HC	11.1	8.6	8.6

Notes:
LW CMU is a Light Weight Concrete Masonry Unit per ASTM C 90, Calculated at 105 PCF density
MW CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90, Calculated at 115 PCF density
NW CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90, Calculated at 125 PCF density
Clay Unit is a Hollow Clay Unit per ASTM C 652, Calculated at 130 PCF density
Values include air films on inner and outer surfaces.
Calculations based on Energy Calculations and Data, CMACN, 1986
Grouted Cells at 32" X 48" in Partly Grouted Walls
Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada

Table B-5–Properties of Solid Unit Masonry and Solid Concrete Walls

Type		Layer Thickness, inches									
		3	4	5	6	7	8	9	10	11	12
LW CMU	U	na	0.71	0.64	na	na	na	na	na	na	na
	Rw	na	1.4	1.6	na	na	na	na	na	na	na
	HC	na	7.00	8.75	na	na	na	na	na	na	na
MW CMU	U	na	0.76	0.70	na	na	na	na	na	na	na
	Rw	na	1.3	1.4	na	na	na	na	na	na	na
	HC	na	7.67	9.58	na	na	na	na	na	na	na
NW CMU	U	0.89	0.82	0.76	na	na	na	na	na	na	na
	Rw	1.1	1.2	1.3	na	na	na	na	na	na	na
	HC	6.25	8.33	10.42	na	na	na	na	na	na	na
Clay Brick	U	0.80	0.72	0.66	na	na	na	na	na	na	na
	Rw	1.3	1.4	1.5	na	na	na	na	na	na	na
	HC	6.30	8.40	10.43	na	na	na	na	na	na	na
Concrete	U	0.96	0.91	0.86	0.82	0.78	0.74	0.71	0.68	0.65	0.63
	Rw	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6
	HC	7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00	26.40	28.80

Notes:
LW CMU is a Light Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 105 PCF density
MW CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 115 PCF density
NW CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 125 PCF density
Clay Brick is a Clay Unit per ASTM C 62, Calculated at 130 PCF density
Concrete is structural poured or precast concrete, Calculated at 144 PCF density
Calculations based on Energy Calculations and Data, CMACN, 1986
Values include air films on inner and outer surfaces.
Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada

Table B-6–Effective R-values for Interior Insulation Layers on Structural Mass Walls

Type Actual Thick	Frame	**Furring space R-value without framing effects** 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Any	None	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5
0.5"	Wood	1.3	1.3	1.9	2.4	2.7	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	0.9	0.9	1.1	1.1	1.2	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
0.75"	Wood	1.4	1.4	2.1	2.7	3.1	3.5	3.8	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	1.0	1.0	1.3	1.4	1.5	1.5	1.6	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
1.0"	Wood	1.3	1.5	2.2	2.9	3.4	3.9	4.3	4.6	4.9	na	na	na	na	na	na	na	na	na	na	na	na	na
	Metal	1.0	1.1	1.4	1.6	1.7	1.8	1.8	1.9	1.9	na	na	na	na	na	na	na	na	na	na	na	na	na
1.5"	Wood	1.3	1.5	2.4	3.1	3.8	4.4	4.9	5.4	5.8	6.2	6.5	6.8	7.1	na	na	na	na	na	na	na	na	na
	Metal	1.1	1.2	1.6	1.9	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.6	2.7	na	na	na	na	na	na	na	na	na
2"	Wood	1.4	1.5	2.5	3.3	4.0	4.7	5.3	5.9	6.4	6.9	7.3	7.7	8.1	8.4	8.7	9.0	9.3	na	na	na	na	na
	Metal	1.1	1.2	1.7	2.1	2.3	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.4	na	na	na	na	na
2.5"	Wood	1.4	1.5	2.5	3.4	4.2	4.9	5.6	6.3	6.8	7.4	7.9	8.4	8.8	9.2	9.6	10.0	10.3	10.6	10.9	11.2	11.5	na
	Metal	1.2	1.3	1.8	2.3	2.6	2.8	3.0	3.2	3.3	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.1	na
3"	Wood	1.4	1.5	2.5	3.5	4.3	5.1	5.8	6.5	7.2	7.8	8.3	8.9	9.4	9.9	10.3	10.7	11.1	11.5	11.9	12.2	12.5	12.9
	Metal	1.2	1.3	1.9	2.4	2.8	3.1	3.3	3.5	3.7	3.8	4.0	4.1	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.7	4.8
3.5"	Wood	1.4	1.5	2.6	3.5	4.4	5.2	6.0	6.7	7.4	8.1	8.7	9.3	9.8	10.4	10.9	11.3	11.8	12.2	12.6	13.0	13.4	13.8
	Metal	1.2	1.3	2.0	2.5	2.9	3.2	3.5	3.8	4.0	4.2	4.3	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.1	5.2	5.2	5.3
4"	Wood	1.4	1.6	2.6	3.6	4.5	5.3	6.1	6.9	7.6	8.3	9.0	9.6	10.2	10.8	11.3	11.9	12.4	12.8	13.3	13.7	14.2	14.6
	Metal	1.2	1.3	2.0	2.6	3.0	3.4	3.7	4.0	4.2	4.5	4.6	4.8	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.8
4.5"	Wood	1.4	1.6	2.6	3.6	4.5	5.4	6.2	7.1	7.8	8.5	9.2	9.9	10.5	11.2	11.7	12.3	12.8	13.3	13.8	14.3	14.8	15.2
	Metal	1.2	1.3	2.1	2.6	3.1	3.5	3.9	4.2	4.5	4.7	4.9	5.1	5.3	5.4	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3
5"	Wood	1.4	1.6	2.6	3.6	4.6	5.5	6.3	7.2	8	8.7	9.4	10.1	10.8	11.5	12.1	12.7	13.2	13.8	14.3	14.8	15.3	15.8
	Metal	1.2	1.4	2.1	2.7	3.2	3.7	4.1	4.4	4.7	5.0	5.2	5.4	5.6	5.8	5.9	6.1	6.2	6.3	6.5	6.6	6.7	6.8
5.5"	Wood	1.4	1.6	2.6	3.6	4.6	5.5	6.4	7.3	8.1	8.9	9.6	10.3	11.0	11.7	12.4	13.0	13.6	14.2	14.7	15.3	15.8	16.3
	Metal	1.3	1.4	2.1	2.8	3.3	3.8	4.2	4.6	4.9	5.2	5.4	5.7	5.9	6.1	6.3	6.4	6.6	6.7	6.8	7.0	7.1	7.2

All furring thickness values given are actual dimensions

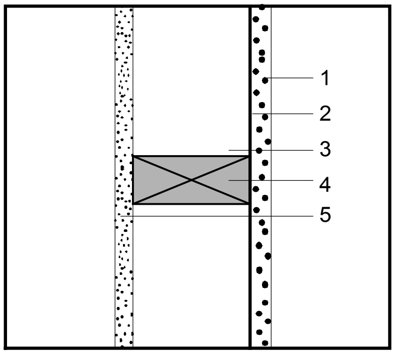
All values include .5" gypboard on the inner surface, interior surface resistances not included

- 24" OC Furring
- 24 Gage, Z-type Metal Furring
- Douglas-Fir Larch Wood Furring, density = 34.9 lb/cu.ft
- Insulation assumed to fill the furring space

[Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada]

Table B-7–Framed Wall/Floor/Ceiling Assembly U-Factors

Reference Name: **W.0.2x4.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- ____ Floor
- ✓ Wall
- ____ Ceiling/Roof

Framing Material: **Wood**
Framing Size: 2 × 4
Framing Spacing: 16 "o.c.
Framing (check one)
Wall: ✓ 15%; ____ 12%; ____ 9% (48"o.c.)
Floor/Ceilin ____ 10%; ____ 7% (24"o.c.); ____ 4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

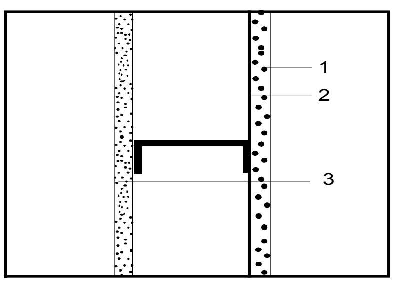
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	3.5" & greater air space; heat sideways	0.850	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	2.390	5.005
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\frac{1/2.390}{1\div R_c}\right) \times \left(\frac{1-15/100}{1-(Fr.\% \div 100)}\right)\right] + \left[\left(\frac{1/5.005}{1\div R_f}\right) \times \left(\frac{15/100}{Fr.\% \div 100}\right)\right] = \boxed{0.385} \text{ Total U-factor}$$

$$\frac{1/0.385}{1\div\text{Total U-factor}} = 2.593 \text{ Total R-Value}$$

Reference Name: **W.0.S2x4.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- ____ Floor
- ✓ Wall
- ____ Ceiling/Roof

Framing Material: **Metal**
Framing Spacing: 16 "o.c.
Framing Size: Actual Depth 3.625; Actual Width 1.625
Cavity Insulation: R-value 0.850; Knock-out (%) 15.00
Insulation Tape R- Web 0.060; Interior Flange 0.0; Exterior 0.0

List of Construction Components

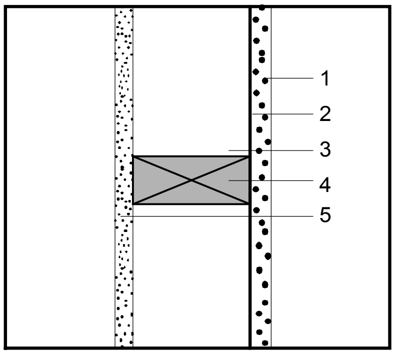
		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.50 in gypsum or plaster board	0.450
4.		
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.449}$ **Total U-factor**

$$\frac{1/0.449}{1\div\text{Total U-factor}} = 2.23 \text{ Total R-Value}$$

Reference Name: **W.0.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 4	
Framing Spacing:	24 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

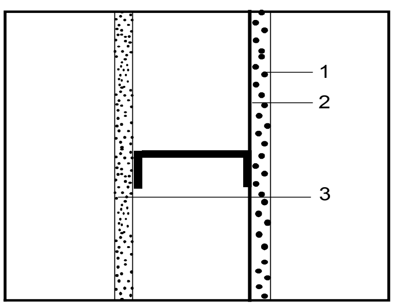
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	3.5" & greater air space; heat sideways	0.850	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	2.390	5.005
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/2.390}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{1\text{-}12/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/5.005}\right) \times \left(\underset{\text{Fr.\%}\div 100}{12/100}\right)\right] = \boxed{0.392}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.392} = 2.549\ \textbf{Total R-Value}$$

Reference Name: **W.0.S2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
	✓	Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	24 "o.c.	
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	0.850
	Knock-out (%)	15.00
	Web	0.060
Insulation Tape R-	Interior Flange	0.0
	Exterior	0.0

List of Construction Components

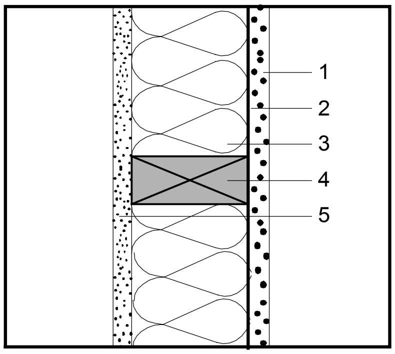
		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.50 in gypsum or plaster board	0.450
4.		
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.443}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.443} = 2.260\ \textbf{Total R-Value}$$

Reference Name: **W.7.2x4.16**



Sketch of Construction Assembly

Assembly Type:		Floor	
(check one)	✓	Wall	
		Ceiling/Roof	
Framing Material:	**Wood**		
Framing Size:	2 × 4		
Framing Spacing:	16 "o.c.		
Framing	Wall:	✓	15%
(check one)			12%
			9% (48"o.c.)
	Floor/Ceilin		10%
			7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components

	List of Construction Components	R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-7 fiberglass insulation	7.000	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	8.540	5.005
		R_c	R_f

Framing Adjustment Calculation:

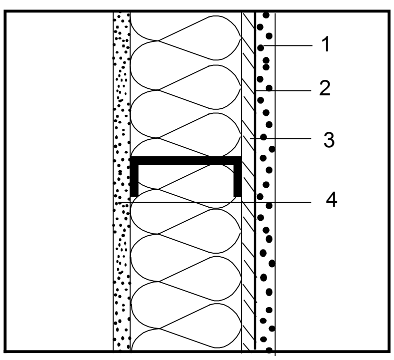
$$\left[\left(\frac{1/8.540}{1 \div R_c}\right) \times \left(\frac{1\text{-}15/100}{1\text{-}(\text{Fr.\%} \div 100)}\right)\right] + \left[\left(\frac{1/5.005}{1 \div R_f}\right) \times \left(\frac{15/100}{\text{Fr.\%} \div 100}\right)\right] = \boxed{0.130}$$

Total U-factor

$$\frac{1/0.130}{1 \div \text{Total U-factor}} = 7.69$$

Total R-Value

Reference Name: **W.7.S2x4.16**



Sketch of Construction Assembly

Assembly Type:			Floor
(check one)		✓	Wall
			Ceiling/Roof
Framing Material:		**Metal**	
Framing Spacing:		16 "o.c.	
Framing Size:	Actual Depth	3.625	
	Actual Width	1.625	
Cavity Insulation:	R-value	7.00	
	Knock-out (%)	15.00	
	Web	0.060	
Insulation Tape R-	Interior Flange	0.0	
	Exterior	0.0	

List of Construction Components

	List of Construction Components	R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.50 in polyisocyanurate	3.520
4.	0.50 in gypsum or plaster board	0.450
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

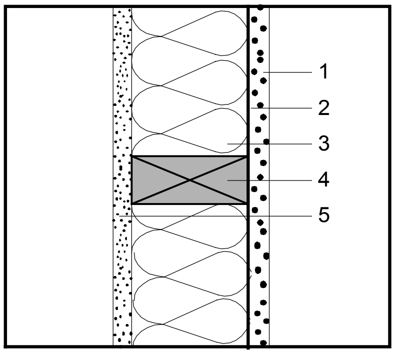
From EZFRAME $= \boxed{0.125}$

Total U-factor

$$\frac{1/0.125}{1 \div \text{Total U-factor}} = 7.990$$

Total R-Value

Reference Name: **W.7.2x4.24**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 4	
Framing Spacing:	24 “o.c.	
Framing (check one)	Wall:	15%
	✓	12%
		9% (48”o.c.)
	Floor/Ceilin	10%
		7% (24”o.c.)
		4% (48”o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

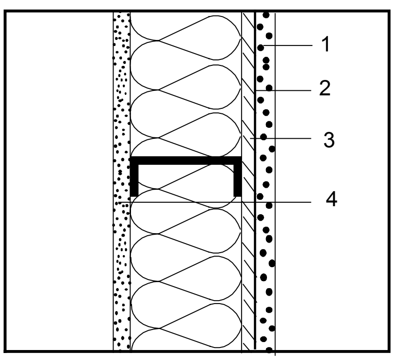
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-7 Fiberglass Insulation	7.000	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	8.540	5.005
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/8.540}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{1-12/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/5.005}\right) \times \left(\underset{\text{Fr.\%}\div 100}{12/100}\right)\right] = \boxed{0.127} \text{ Total U-factor}$$

$$\underset{1\div \text{Total U-factor}}{1/0.127} = 7.874 \text{ Total R-Value}$$

Reference Name: **W.7.S2x4.24**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	24 “o.c.	
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	7.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	0.0
	Exterior	0.0

List of Construction Components

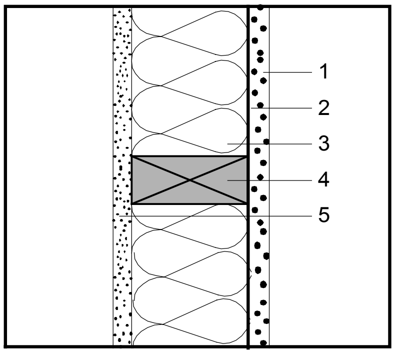
		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.50 in polyisocyanurate	3.520
4.	0.50 in gypsum or plaster board	0.450
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.117}$ **Total U-factor**

$$\underset{1\div \text{Total U-factor}}{1/0.117} = 8.530 \text{ Total R-Value}$$

Reference Name: **W.11.2x4.16**



Sketch of Construction Assembly

Assembly Type:		Floor	
(check one)	✓	Wall	
		Ceiling/Roof	
Framing Material:	**Wood**		
Framing Size:	2 × 4		
Framing Spacing:	16 "o.c.		
Framing (check one)	Wall:	✓	15%
			12%
			9% (48"o.c.)
	Floor/Ceilin		10%
			7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components / **R-Value**

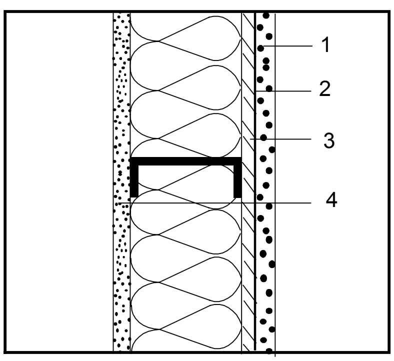
		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-11 fiberglass insulation	11.000	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	12.540	5.005
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1 \div R_c}{1/12.540}\right) \times \left(\underset{1-(\text{Fr.\%} \div 100)}{1-15/100}\right)\right] + \left[\left(\underset{1 \div R_f}{1/5.005}\right) \times \left(\underset{\text{Fr.\%} \div 100}{15/100}\right)\right] = \underset{\textbf{Total U-factor}}{\boxed{0.098}}$$

$$\underset{1 \div \text{Total U-factor}}{1/0.098} = \underset{\textbf{Total R-Value}}{10.204}$$

Reference Name: **W.11.S2x4.16**



Sketch of Construction Assembly

Assembly Type:			Floor
(check one)	✓		Wall
			Ceiling/Roof
Framing Material:	**Metal**		
Framing Spacing:	16 "o.c.		
Framing Size:		Actual Depth	3.625
		Actual Width	1.625
Cavity Insulation:		R-value	11.000
		Knock-out (%)	15.000
		Web	0.060
Insulation Tape R-		Interior Flange	0.0
		Exterior	0.0

List of Construction Components / **R-Value**

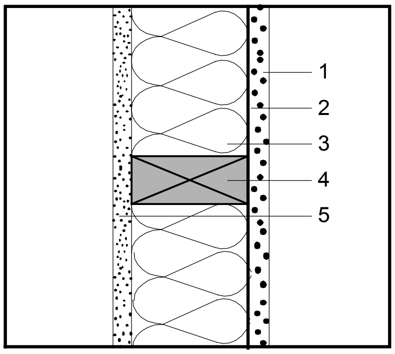
		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.75 in polyisocyanurate	5.280
4.	0.50 in gypsum or plaster board	0.450
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = **0.096** **Total U-factor**

$$\underset{1 \div \text{Total U-factor}}{1/0.096} = \underset{\textbf{Total R-Value}}{10.360}$$

Reference Name: **W.11.2x4.24**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 4	
Framing Spacing:	24	"o.c.
Framing (check one)	Wall: ✓	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components — **R-Value**

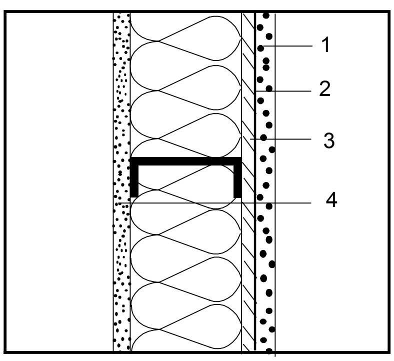
		Cavity (R_c)	**Frame (R_f)**
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-11 fiberglass insulation	11.000	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	12.540	5.005
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\frac{1/12.540}{1 \div R}\right) \times \left(\frac{1-12/100}{1-(\text{Fr.}\% \div 100)}\right)\right] + \left[\left(\frac{1/5.005}{1 \div R_f}\right) \times \left(\frac{12/100}{\text{Fr.}\% \div 100}\right)\right] = \boxed{0.094}\ \textbf{Total U-factor}$$

$$\frac{1/0.094}{1 \div \text{Total U-factor}} = \frac{10.638}{\textbf{Total R-Value}}$$

Reference Name: **W.11.S2x4.24**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	24	"o.c.
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	11.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	0.0
	Exterior	0.0

List of Construction Components — **R-Value**

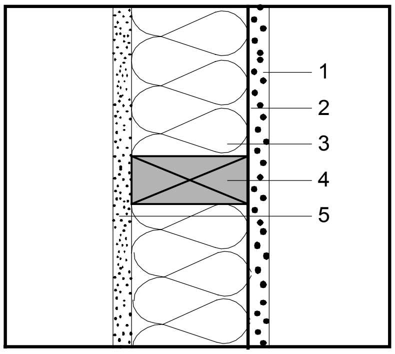
		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.75 in polyisocyanurate	5.280
4.	0.50 in gypsum or plaster board	0.450
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.090}$ **Total U-factor**

$$\frac{1/0.090}{1 \div \text{Total U-factor}} = \frac{11.140}{\textbf{Total R-Value}}$$

Reference Name: **W.13.2x4.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- ___ Floor
- ✓ Wall
- ___ Ceiling/Roof

Framing Material: Wood
Framing Size: 2 × 4
Framing Spacing: 16 "o.c.
Framing (check one)
Wall: ✓ 15% ; ___ 12% ; ___ 9% (48"o.c.)
Floor/Ceilin ___ 10% ; ___ 7% (24"o.c.) ; ___ 4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-13 fiberglass insulation	13.000	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	14.540	5.005
		R_c	R_f

Framing Adjustment Calculation:

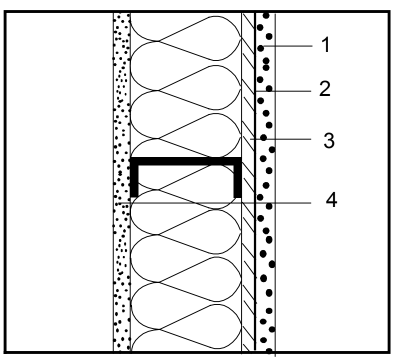
$$[(\underbrace{1/14.540}_{1\div R_c}) \times (\underbrace{1\text{-}15/100}_{1-(Fr.\% \div 100)})] + [(\underbrace{1/5.005}_{1\div R_f}) \times (\underbrace{15/100}_{Fr.\% \div 100})] = \boxed{0.088}$$

Total U-factor

$$\underbrace{1/0.088}_{1\div\text{Total U-factor}} = 11.364$$

Total R-Value

Reference Name: **W.13.S2x4.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- ___ Floor
- ✓ Wall
- ___ Ceiling/Roof

Framing Material: Metal
Framing Spacing: 16 "o.c.
Framing Size: Actual Depth 3.625; Actual Width 1.625
Cavity Insulation: R-value 13.000; Knock-out (%) 15.000; Web 0.060
Insulation Tape R- Interior Flange 0.0; Exterior 0.0

List of Construction Components		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	1.00 in Polyisocyanurate	7.040
4.	0.50 in gypsum or plaster board	0.450
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

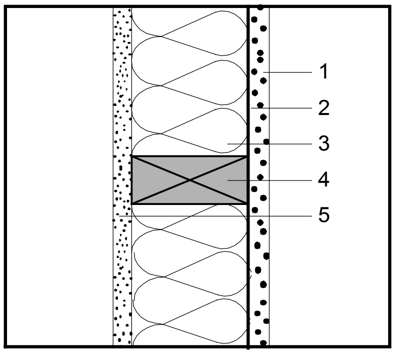
From EZFRAME = $\boxed{0.081}$

Total U-factor

$$\underbrace{1/0.081}_{1\div\text{Total U-factor}} = 12.330$$

Total R-Value

Reference Name: **W.13.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one) ___ Floor ✓ Wall ___ Ceiling/Roof

Framing Material: Wood

Framing Size: 2 × 4

Framing Spacing: 24 "o.c.

Framing (check one)
Wall: ✓ 15% ; ___ 12% ; ___ 9% (48"o.c.)
Floor/Ceilin ___ 10% ; ___ 7% (24"o.c.) ; ___ 4% (48"o.c.)

Wall Weight / sf: NA
(Packages only)

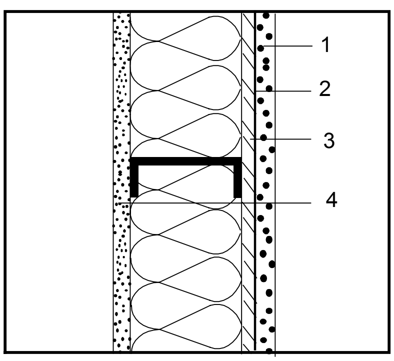
List of Construction Components		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-13 fiberglass insulation	13.000	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	14.540	5.005
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\frac{1/14.540}{1 \div R_c}\right) \times \left(\frac{1-12/100}{1-(\text{Fr.\%} \div 100)}\right)\right] + \left[\left(\frac{1/5.005}{1 \div R_f}\right) \times \left(\frac{12/100}{\text{Fr.\%} \div 100}\right)\right] = \boxed{0.084} \text{ Total U-factor}$$

$$\frac{1/0.084}{1 \div \text{Total U-factor}} = 11.905 \text{ Total R-Value}$$

Reference Name: **W.13.S2x4.24**



Sketch of Construction Assembly

Assembly Type: (Check one) ___ Floor ✓ Wall ___ Ceiling/Roof

Framing Material: Metal

Framing Spacing: 24 "o.c.

Framing Size: Actual Depth 3.625 ; Actual Width 1.625

Cavity Insulation: R-value 13.00 ; Knock-out (%) 15.00

Insulation Tape R- Web 0.060 ; Interior Flange 0.0 ; Exterior 0.0

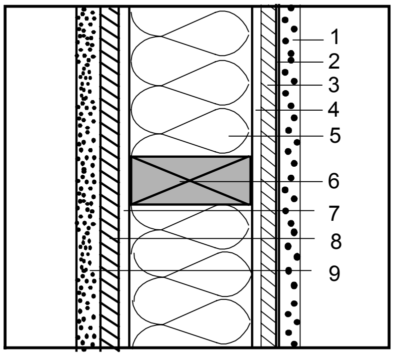
List of Construction Components		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.75 in polyisocyanurate	5.280
4.	0.50 in gypsum or plaster board	0.450
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.087}$ **Total U-factor**

$$\frac{1/0.087}{1 \div \text{Total U-factor}} = 11.460 \text{ Total R-Value}$$

Reference Name: **WP.14.2x4.48**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 4	
Framing Spacing:	48 "o.c.	
Framing (check one)	Wall:	15%
		12%
	✓	9% (48"o.c.)
	Floor/Ceilin	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components — **R-Value**

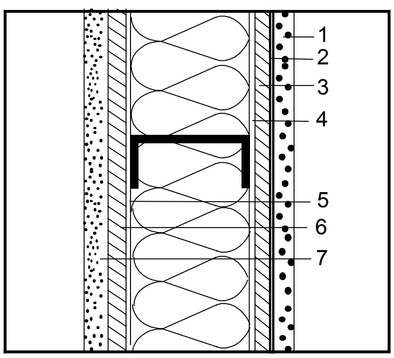
		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	0.375 in plywood	0.470	0.470
4.	0.875 in Furring Channel	0.800	0.800
5.	3 5/8 in EPS foam insulation @ R-3.85/in	13.956	-----
6.	2x4 in fir framing	-----	3.465
7.	0.875 in Furring Channel	0.800	0.800
8.	0.375 in plywood	0.470	0.470
9.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	18.036	7.545
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/18.036}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{1-9/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/7.545}\right) \times \left(\underset{\text{Fr.\%}\div 100}{9/100}\right)\right] = \boxed{0.062}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.062} = 16.129\ \textbf{Total R-Value}$$

Reference Name: **WP.14.S2x4.48**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	48 "o.c.	
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	14.00
	Knock-out (%)	15.00
	Web	0.060
Insulation Tape R-	Interior Flange	0.0
	Exterior	0.0

List of Construction Components — **R-Value**

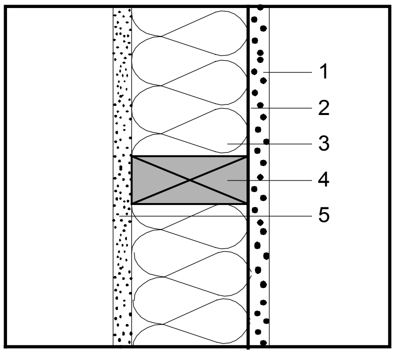
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	1.00 in polyisocyanurate	7.040
4.	0.875 in Furring Channel	0.800
5.	0.875 in Furring Channel	0.800
6.	0.375 in plywood	0.470
7.	0.50 in gypsum or plaster board	0.450
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME $= \boxed{0.062}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.062} = 16.26\ \textbf{Total R-Value}$$

Reference Name: **W.15.2x4.16**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2	4
Framing Spacing:	16	"o.c.

Framing	Wall:		15%
(check one)		✓	12%
			9% (48"o.c.)
	Floor/Ceilin		10%
			7% (24"o.c.)
			4% (48"o.c.)

Wall Weight / sf: NA
(Packages only)

List of Construction Components

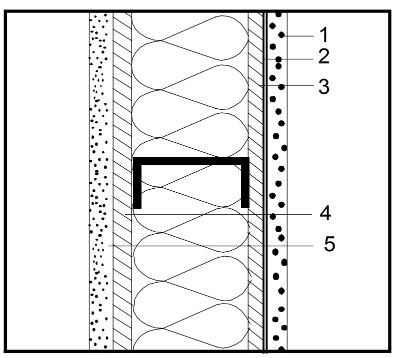
	List of Construction Components	R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-15 fiberglass insulation	15.000	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	16.540	5.005
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R}{1/16.540}\right) \times \left(\underset{1-(\text{Fr.\%} \div 100)}{1-15/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/5.005}\right) \times \left(\underset{\text{Fr.\%} \div 100}{15/100}\right)\right] = \underset{\textbf{Total U-factor}}{\boxed{0.081}}$$

$$\frac{1/0.081}{1\div\text{Total U-factor}} = \underset{\textbf{Total R-Value}}{12.346}$$

Reference Name: **W.15.S2x4.16**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16	"o.c.
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	15.00
	Knock-out (%)	15.00
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

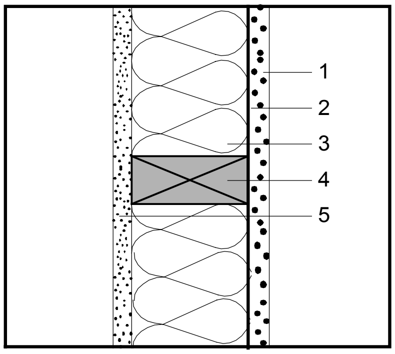
	List of Construction Components	R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.50 in Polyisocyanurate	3.520
4.	0.50 in Polyisocyanurate	3.520
5.	0.50 in gypsum or plaster board	0.450
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME $= \underset{\textbf{Total U-factor}}{\boxed{0.080}}$

$$\frac{1/0.080}{1\div\text{Total U-factor}} = \underset{\textbf{Total R-Value}}{12.510}$$

Reference Name: **W.15.2x4.24**



Sketch of Construction Assembly

Assembly Type:	✓	Floor
(check one)		Wall
		Ceiling/Roof
Framing Material:	Wood	
Framing Size:	2	4
Framing Spacing:	24 × "o.c.	
Framing (check one)	Wall:	15%
		12%
	✓	9% (48"o.c.)
	Floor/Ceilin	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

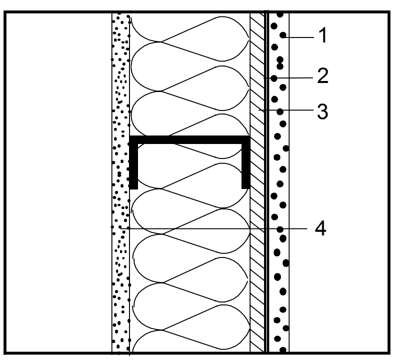
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-15 fiberglass insulation	15.000	-----
4.	2x4 in fir framing	-----	3.465
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	16.540	5.005
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/16.540}\right) \times \left(\underset{1-(\text{Fr.}\%\div 100)}{1\text{-}12/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/5.005}\right) \times \left(\underset{\text{Fr.}\%\div 100}{12/100}\right)\right] = \boxed{0.077}\ \textbf{Total U-factor}$$

$$\underset{1\div \text{Total U-factor}}{1/0.077} = 12.987\ \textbf{Total R-Value}$$

Reference Name: **W.15.S2x4.24**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	Metal	
Framing Spacing:	24	"o.c.
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	15.00
	Knock-out (%)	15.00
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

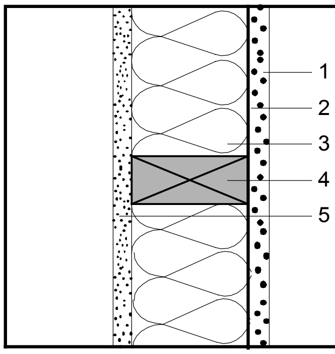
		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	1 in Polyisocyanurate	7.040
4.	0.50 in gypsum or plaster board	0.450
5.		
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.074}$ **Total U-factor**

$$\underset{1\div \text{Total U-factor}}{1/0.074} = 13.470\ \textbf{Total R-Value}$$

Reference Name: **W.19.2x6.16**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 6	
Framing Spacing:	16 "o.c.	
Framing (check one)	Wall: ✓	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

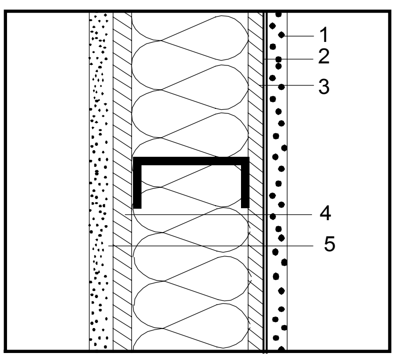
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-19 fiberglass inuslation	19.000	-----
4.	2x6 in fir framing	-----	5.445
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	20.540	6.985
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underbrace{1/20.540}_{1\div R_c}\right) \times \left(\underbrace{1-15/100}_{1-(\text{Fr.}\% \div 100)}\right)\right] + \left[\left(\underbrace{1/6.985}_{1\div R_f}\right) \times \left(\underbrace{15/100}_{\text{Fr.}\% \div 100}\right)\right] = \boxed{0.063}\ \textbf{Total U-factor}$$

$$\underbrace{1/0.063}_{1\div\text{Total U-factor}} = \underbrace{15.873}_{\textbf{Total R-Value}}$$

Reference Name: **W.19.S2x6.16**



Sketch of Construction Assembly

Assembly Type:		Floor
(check one)	✓	Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	6.000
	Actual Width	1.625
Cavity Insulation:	R-value	19.00
	Knock-out (%)	15.00
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

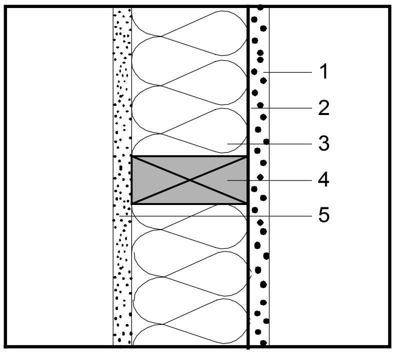
		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.75 in polyiscyanurate	5.280
4.	0.50 in polyiscyanurate	3.520
5.	0.50 in gypsum or plaster board	0.450
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME $= \boxed{0.064}$ **Total U-factor**

$$\underbrace{1/0.064}_{1\div\text{Total U-factor}} = \underbrace{15.530}_{\textbf{Total R-Value}}$$

Reference Name: **W.19.2x6.24**



Sketch of Construction Assembly

Assembly Type: (check one)
- ___ Floor
- ✓ Wall
- ___ Ceiling/Roof

Framing Material: **Wood**
Framing Size: 2 × 6
Framing Spacing: 24 "o.c.
Framing (check one)
Wall: ___ 15% / ✓ 12% / ___ 9% (48"o.c.)
Floor/Ceilin ___ 10% / ___ 7% (24"o.c.) / ___ 4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

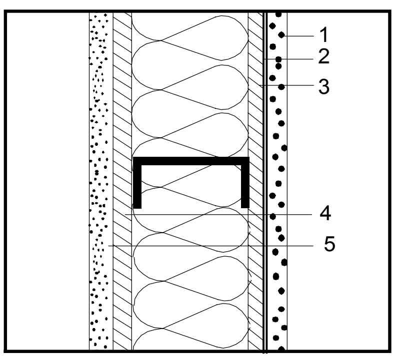
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-19 fiberglass insulation	19.000	-----
4.	2x6 in fir framing	-----	5.445
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	20.540	6.985
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/20.540}\right) \times \left(\underset{1-(Fr.\% \div 100)}{1-12/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/6.985}\right) \times \left(\underset{Fr.\% \div 100}{12/100}\right)\right] = \boxed{0.060} \text{ Total U-factor}$$

$$\underset{1\div \text{Total U-factor}}{1/0.060} = \underset{\text{Total R-Value}}{16.666}$$

Reference Name: **W.19.S2x6.24**



Sketch of Construction Assembly

Assembly Type: (check one)
- ___ Floor
- ✓ Wall
- ___ Ceiling/Roof

Framing Material: **Metal**
Framing Spacing: 24 "o.c.
Framing Size: Actual Depth 6.000; Actual Width 1.625
Cavity Insulation: R-value 19.00; Knock-out (%) 15.00; Web 0.060
Insulation Tape R- Interior Flange ___; Exterior ___

List of Construction Components

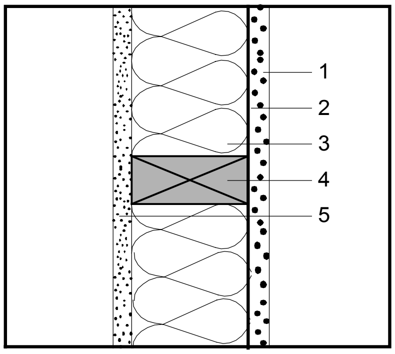
		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	0.75 in polyisocyanurate	5.280
4.	0.50 in polyisocyanurate	3.520
5.	0.50 in gypsum board	0.450
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.060}$ **Total U-factor**

$$\underset{1\div \text{Total U-factor}}{1/0.060} = \underset{\text{Total R-Value}}{16.750}$$

Reference Name: **W.21.2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- Floor
- ✓ Wall
- Ceiling/Roof

Framing Material: **Wood**
Framing Size: 2 × 6
Framing Spacing: 16 "o.c.
Framing (check one)
- Wall: ✓ 15%
- 12%
- 9% (48"o.c.)
- Floor/Ceilin: 10%
- 7% (24"o.c.)
- 4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

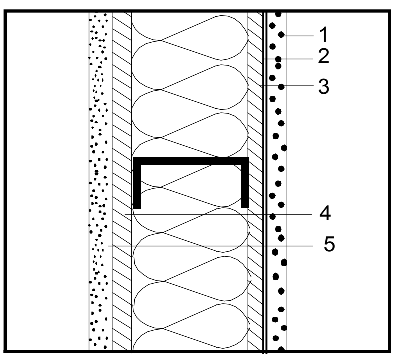
	List of Construction Components	Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-21 fiberglass insulation	21.000	-----
4.	2x6 in fir framing	-----	5.445
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	22.540	6.985
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{\underline{1/22.540}}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{\underline{1-15/100}}\right)\right] + \left[\left(\underset{1\div Rf}{\underline{1/6.985}}\right) \times \left(\underset{\text{Fr.\%}\div 100}{\underline{15/100}}\right)\right] = \boxed{0.059}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{\underline{1/0.059}} = \underset{\textbf{Total R-Value}}{\underline{16.949}}$$

Reference Name: **W.21.S2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- Floor
- ✓ Wall
- Ceiling/Roof

Framing Material: **Metal**
Framing Spacing: 16 "o.c.
Framing Size: Actual Depth 6.000; Actual Width 1.625
Cavity Insulation: R-value 21.00; Knock-out (%) 15.00; Web 0.060
Insulation Tape R- Interior Flange ; Exterior

List of Construction Components

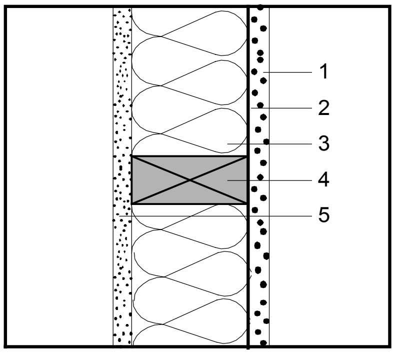
	List of Construction Components	R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	1.0 in polyisocyanurate	7.040
4.	0.5 in polyisocyanurate	3.520
5.	0.50 in gypsum or plaster board	0.450
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.057}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{\underline{1/0.057}} = \underset{\textbf{Total R-Value}}{\underline{17.440}}$$

Reference Name: **W.21.2x6.24**



Sketch of Construction Assembly

Assembly Type: (check one) ___ Floor / ✓ Wall / ___ Ceiling/Roof

Framing Material: Wood

Framing Size: 2 × 6

Framing Spacing: 24 "o.c.

Framing (check one) Wall: ___ 15% / ✓ 12% / ___ 9% (48"o.c.)

Floor/Ceilin ___ 10% / ___ 7% (24"o.c.) / ___ 4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

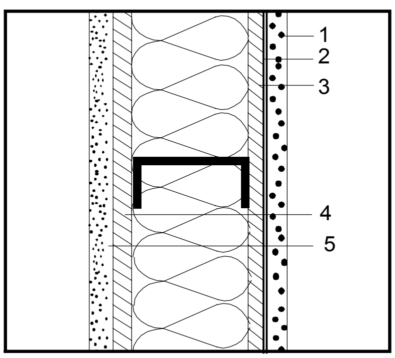
List of Construction Components		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	R-21 fiberglass insulation	21.000	-----
4.	2x6 in fir framing	-----	5.445
5.	0.50 in gypsum or plaster board	0.450	0.450
6.			
7.			
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	22.540	6.985
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/22.540}\right) \times \left(\underset{1-(\text{Fr.\%} \div 100)}{1\text{-}12/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/6.985}\right) \times \left(\underset{\text{Fr.\%} \div 100}{12/100}\right)\right] = \boxed{0.056} \text{ Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.056} = \underset{\textbf{Total R-Value}}{17.857}$$

Reference Name: **W.21.S2x6.24**



Sketch of Construction Assembly

Assembly Type: (check one) ___ Floor / ✓ Wall / ___ Ceiling/Roof

Framing Material: Metal

Framing Spacing: 24 "o.c.

Framing Size: Actual Depth 6.000; Actual Width 1.625

Cavity Insulation: R-value 21.000; Knock-out (%) 15.000; Web 0.060

Insulation Tape R- Interior Flange ___; Exterior ___

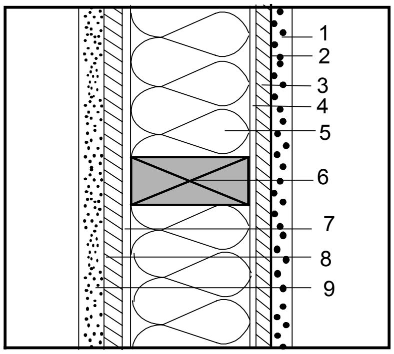
List of Construction Components		R-Value
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	1.0 in polyisocyanurate	7.040
4.	0.5 in polyisocyanurate	3.520
5.	0.50 in gypsum or plaster board	0.450
6.		
7.		
	Inside Surface Air Film	0.680

Calculation:

From EZFRAME = $\boxed{0.053}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.053} = \underset{\textbf{Total R-Value}}{18.720}$$

Reference Name: **WP.22.2x6.48**



Sketch of Construction Assembly

Assembly Type: (check one)
- Floor
- ✓ Wall
- Ceiling/Roof

Framing Material: **Wood**
Framing Size: 2 × 6
Framing Spacing: 48 "o.c.
Framing (check one)
- Wall: 15%
- 12%
- ✓ 9% (48"o.c.)
- Floor/Ceilin 10%
- 7% (24"o.c.)
- 4% (48"o.c.)

Wall Weight / sf: NA
(Packages only)

List of Construction Components		**R-Value** Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	0.875 in stucco	0.180	0.180
2.	Building paper (felt)	0.060	0.060
3.	0.375 in plywood	0.470	0.470
4.	0.875 in Furring Channel	0.800	0.800
5.	R-21.656 EPS foam insulation	21.656	-----
6.	2x6 in fir framing	-----	5.445
7.	0.875 in Furring Channel	0.800	0.800
8.	0.375 in plywood	0.470	0.470
9.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.680	0.680
	Total Unadjusted R-Values:	25.736	9.525
		R_c	R_f

Framing Adjustment Calculation:

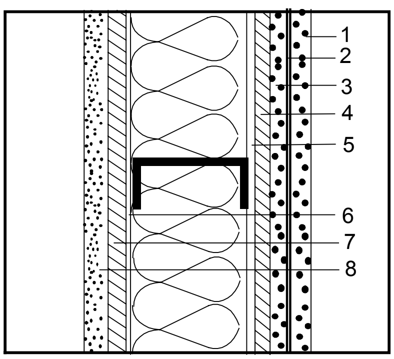
$$\left[\left(\underset{1\div R_c}{\underline{1/25.736}}\right) \times \left(\underset{1\text{-(Fr.\% }\div 100)}{\underline{1\text{-}9/100}}\right)\right] + \left[\left(\underset{1\div R_f}{\underline{1/9.525}}\right) \times \left(\underset{\text{Fr.\% }\div 100}{\underline{9/100}}\right)\right] = \boxed{0.049}$$

Total U-factor

$$\underset{1\div\text{Total U-factor}}{\underline{1/0.049}} = 20.408$$

Total R-Value

Reference Name: **WP.22.S2x6.48**



Sketch of Construction Assembly

Assembly Type: (check one)
- Floor
- ✓ Wall
- Ceiling/Roof

Framing Material: **Metal**
Framing Spacing: 48 "o.c.
Framing Size: Actual Depth 6.000; Actual Width 1.625
Cavity Insulation: R-value 21.700; Knock-out (%) 15.00; Web 0.060
Insulation Tape R- Interior Flange; Exterior

List of Construction Components		**R-Value**
	Outside Surface Air Film	0.170
1.	0.875 in stucco	0.180
2.	Building paper (felt)	0.060
3.	1.50 in polyisocyanurate	10.560
4.	0.50 in plywood	0.630
5.	0.875 in Furring channel	0.800
6.	0.875 in Furring channel	0.800
7.	0.50 in plywood	0.630
8.	0.50 in gypsum or plaster board	0.450
	Inside Surface Air Film	0.680

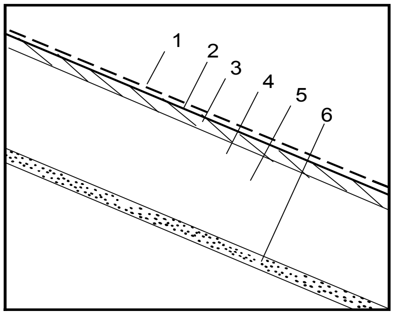
Calculation:

From EZFRAME = $\boxed{0.044}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{\underline{1/0.044}} = 22.83$$

Total R-Value

Reference Name: **R.0.2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)

	Floor
	Wall
✓	Ceiling/Roof

Framing Material: **Wood**

Framing Size: 2 × 6

Framing Spacing: 16 "o.c.

Framing (check one)

Wall:		15%
		12%
		9% (48"o.c.)
Floor/Ceilin	✓	10%
		7% (24"o.c.)
		4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

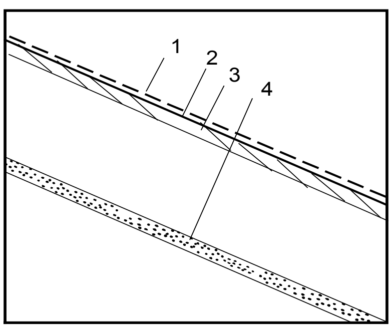
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.5 in & greater air space; heat flow up	0.800	-----
5.	2x6 in fir framing	-----	5.445
6.	0.50 in gypsum or plaster board	0.450	0.450
7.			
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	3.170	7.815
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1 \div R_c}{\underline{1/3.170}}\right) \times \left(\underset{1-(\text{Fr.}\% \div 100)}{\underline{1-10/100}}\right)\right] + \left[\left(\underset{1 \div R_f}{\underline{1/7.815}}\right) \times \left(\underset{\text{Fr.}\% \div 100}{\underline{10/100}}\right)\right] = \underset{\text{Total U-factor}}{\boxed{0.297}}$$

$$\underset{1 \div \text{Total U-factor}}{\underline{1/0.297}} = \underset{\text{Total R-Value}}{\underline{3.367}}$$

Reference Name: **R.0.S2X6.16**



Sketch of Construction Assembly

Assembly Type: (check one)

	Floor
	Wall
✓	Ceiling/Roof

Framing Material: **Metal**

Framing Spacing: 16 "o.c.

Framing Size:	Actual Depth	6.000
	Actual Width	1.625
Cavity Insulation:	R-value	0.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

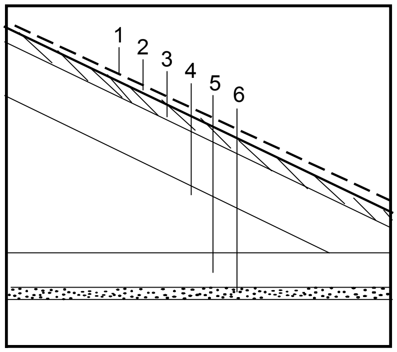
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	0.50 in plywood	0.630
4.	0.50 in gypsum or plaster board	0.450
5.		
6.		
7.		
	Inside Surface Air Film	0.620

Calculation:

From EZFRAME = $\underset{\text{Total U-factor}}{\boxed{0.323}}$

$$\underset{1 \div \text{Total U-factor}}{\underline{1/0.323}} = \underset{\text{Total R-Value}}{\underline{3.090}}$$

Reference Name: **R.0.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)

____	Floor
____	Wall
✓	Ceiling/Roof

Framing Material: **Wood**

Framing Size: 2 × 4

Framing Spacing: 24 "o.c.

Framing (check one)

Wall:	____	15%
	____	12%
	____	9% (48"o.c.)
Floor/Ceilin	____	10%
	✓	7% (24"o.c.)
	____	4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

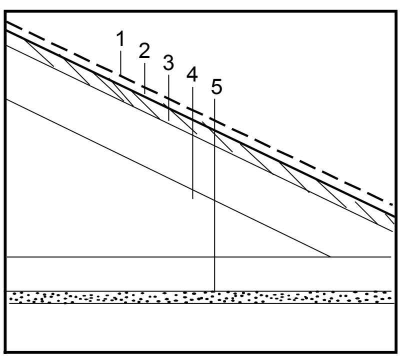
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.5" & greater air space; heat sidways	0.800	0.800
5.	2x4 in fir framing	-----	3.465
6.	0.50 in gypsum or plaster board	0.450	0.450
7.			
	Inside Surface Air Film	0.610	0.610
	Total Unadjusted R-Values:	3.160 (R_c)	6.625 (R_f)

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/3.160}\right) \times \left(\underset{1-(\text{Fr.}\%\div 100)}{1-7/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/6.625}\right) \times \left(\underset{\text{Fr.}\%\div 100}{7/100}\right)\right] = \underset{\textbf{Total U-factor}}{\boxed{0.305}}$$

$$\underset{1\div\text{Total U-factor}}{1/0.305} = \underset{\textbf{Total R-Value}}{3.279}$$

Reference Name: **R.0.S2X4.24**



Sketch of Construction Assembly

Assembly Type: (check one)

____	Floor
____	Wall
✓	Ceiling/Roof

Framing Material: **Metal**

Framing Spacing: 24 "o.c.

Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	0.800
	Knock-out (%)	15.00
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

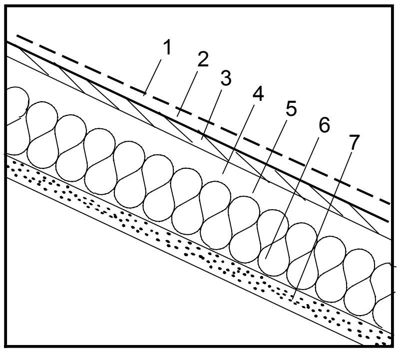
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	0.50 in plywood	0.630
4.	3.5" & greater air space; heat sidways	0.800
5.	0.50 in gypsum or plaster board	0.450
6.		
7.		
	Inside Surface Air Film	0.610

Calculation:

From EZFRAME = $\underset{\textbf{Total U-factor}}{\boxed{0.316}}$

$$\underset{1\div\text{Total U-factor}}{1/0.316} = \underset{\textbf{Total R-Value}}{3.160}$$

Reference Name: **R.11.2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	Wood	
Framing Size:	2 × 6	
Framing Spacing:	16 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin ✓	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

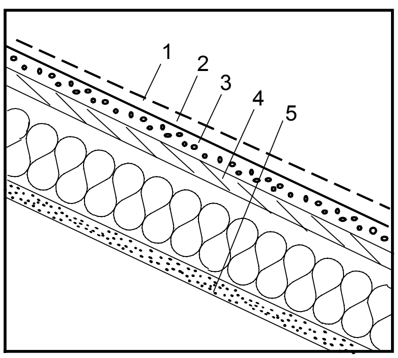
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	2.0 in air space; heat flow up	0.780	-----
5.	2x6 in fir framing	-----	5.445
6.	R-11 fiberglass insulation	11.000	-----
7.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	14.150	7.815
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/14.150}\right) \times \left(\underset{1-(\text{Fr.}\% \div 100)}{1-10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/7.815}\right) \times \left(\underset{\text{Fr.}\% \div 100}{10/100}\right)\right] = \boxed{0.076}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.076} = \underset{\textbf{Total R-Value}}{13.157}$$

Reference Name: **R.11.S2X6.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	Metal	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	6.000
	Actual Width	1.625
Cavity Insulation:	R-value	11.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

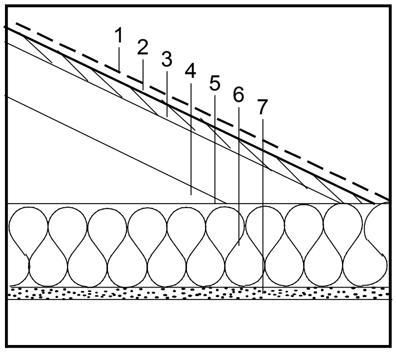
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle	0.440
2.	Building paper (felt)	0.060
3.	0.75 in Polyisocyanurate	5.280
4.	0.625 in Plywood	0.780
5.	0.50 in gypsum or plaster board	0.450
6.		
7.		
	Inside Surface Air Film	0.620

Calculation:

From EZFRAME = $\boxed{0.071}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.071} = \underset{\textbf{Total R-Value}}{14.060}$$

Reference Name: **R.11.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor	
		Wall	
	✓	Ceiling/Roof	
Framing Material:	Wood		
Framing Size:	2 × 4		
Framing Spacing:	24 "o.c.		
Framing (check one)	Wall:		15%
			12%
			9% (48"o.c.)
	Floor/Ceilin		10%
		✓	7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components

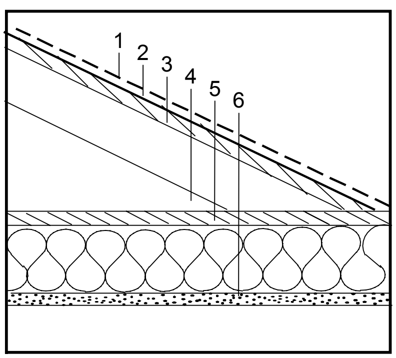
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.50 in & greater air space; heat flow up	0.800	0.800
5.	R-11 fiberglass insulation	11.000	-----
6.	2x4 in fir framing	-----	3.465
7.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.610	0.610
	Total Unadjusted R-Values:	14.160	6.625
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1 \div R_c}{1/14.160}\right) \times \left(\underset{1-(Fr.\% \div 100)}{1\text{-}7/100}\right)\right] + \left[\left(\underset{1 \div R_f}{1/6.625}\right) \times \left(\underset{Fr.\% \div 100}{7/100}\right)\right] = \underset{\textbf{Total U-factor}}{\boxed{0.076}}$$

$$\underset{1 \div \text{Total U-factor}}{1/0.076} = \underset{\textbf{Total R-Value}}{13.157}$$

Reference Name: **R.11.S2X4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	Metal	
Framing Spacing:	24 "o.c.	
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	11.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

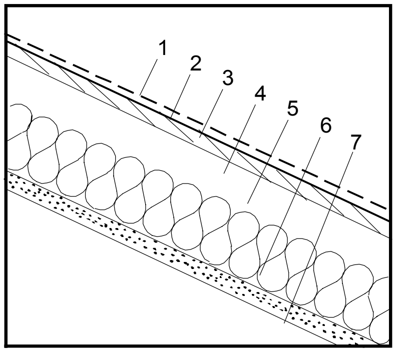
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	0.50 in plywood	0.630
4.	3.50 in & greater air space; heat flow up	0.800
5.	0.75 in Polyisocyanurate	5.280
6.	0.50 in gypsum or plaster board	0.450
7.		
	Inside Surface Air Film	0.610

Calculation:

From EZFRAME = $\underset{\textbf{Total U-factor}}{\boxed{0.069}}$

$$\underset{1 \div \text{Total U-factor}}{1/0.069} = \underset{\textbf{Total R-Value}}{14.500}$$

Reference Name: **R.13.2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- Floor
- Wall
- ✓ Ceiling/Roof

Framing Material: Wood
Framing Size: 2 × 6
Framing Spacing: 16 "o.c.
Framing (check one)

Wall:		15%
		12%
		9% (48"o.c.)
Floor/Ceilin	✓	10%
		7% (24"o.c.)
		4% (48"o.c.)

Wall Weight / sf: NA
(Packages only)

List of Construction Components

		R-Value Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	2.0 in air space: heat flow up	0.780	-----
5.	2x6 in fir framing	-----	5.445
6.	R-13 fiberglass insulation	13.000	-----
7.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	16.150	7.815
		R_c	R_f

Framing Adjustment Calculation:

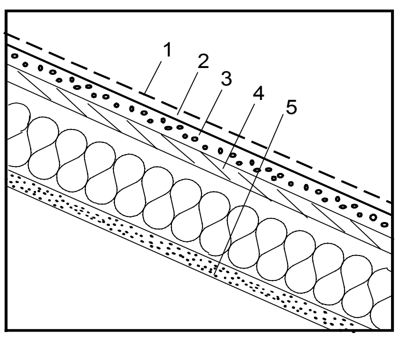
$$\left[\left(\underset{1 \div R_c}{1/16.150}\right) \times \left(\underset{1-(Fr.\% \div 100)}{1-10/100}\right)\right] + \left[\left(\underset{1 \div R_f}{1/7.815}\right) \times \left(\underset{Fr.\% \div 100}{10/100}\right)\right] = \boxed{0.069}$$

Total U-factor

$$\underset{1 \div \text{Total U-factor}}{1/0.069} = 14.493$$

Total R-Value

Reference Name: **R.13.S2X6.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- Floor
- Wall
- ✓ Ceiling/Roof

Framing Material: Metal
Framing Spacing: 16 "o.c.

Framing Size:	Actual Depth	6.000
	Actual Width	1.625
Cavity Insulation:	R-value	13.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	1.00 in polyisocyanurate	7.040
4.	0.50 in plywood	0.630
5.	0.50 in gypsum or plaster board	0.450
6.		
7.		
	Inside Surface Air Film	0.620

Calculation:

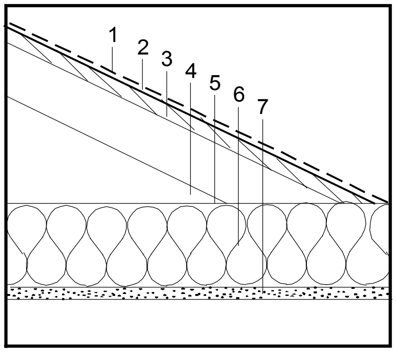
From EZFRAME = $\boxed{0.062}$

Total U-factor

$$\underset{1 \div \text{Total U-factor}}{1/0.062} = 16.130$$

Total R-Value

Reference Name: **R.13.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 4	
Framing Spacing:	24 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin	10%
	✓	7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

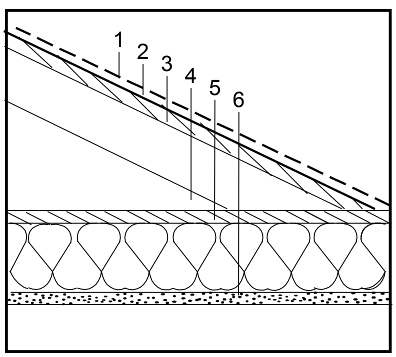
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.50 in & greater air space; heat flow up	0.800	0.800
5.	R-13 fiberglass insulation	13.000	-----
6.	2x4 in fir framing	-----	3.465
7.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.610	0.610
	Total Unadjusted R-Values:	16.160	6.625
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/16.160}\right) \times \left(\underset{1-(\text{Fr.\%} \div 100)}{1-7/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/6.625}\right) \times \left(\underset{\text{Fr.\%} \div 100}{7/100}\right)\right] = \boxed{0.068}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.068} = \underset{\textbf{Total R-Value}}{14.705}$$

Reference Name: **R.13.S2X4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	24 "o.c.	
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	13.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

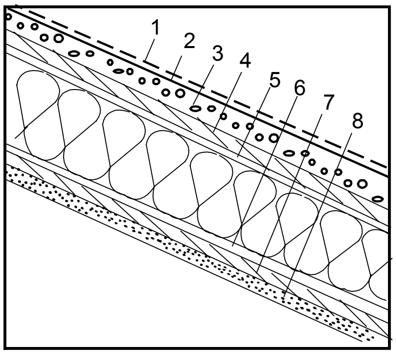
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	0.50 in plywood	0.630
4.	3.50 in & greater air space; heat flow up	0.800
5.	0.75 in Polyisocyanurate	5.280
6.	0.50 in gypsum or plaster board	0.450
7.		
	Inside Surface Air Film	0.610

Calculation:

From EZFRAME = $\boxed{0.066}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.066} = \underset{\textbf{Total R-Value}}{15.100}$$

Reference Name: **RP.14.2x4.48**



Sketch of Construction Assembly

Assembly Type: (check one)

____	Floor
____	Wall
✓	Ceiling/Roof

Framing Material: **Wood**

Framing Size: 2 × 4

Framing Spacing: 48 "o.c.

Framing (check one)

Wall:	____	15%
	____	12%
	____	9% (48"o.c.)
Floor/Ceilin	____	10%
	____	7% (24"o.c.)
	✓	4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

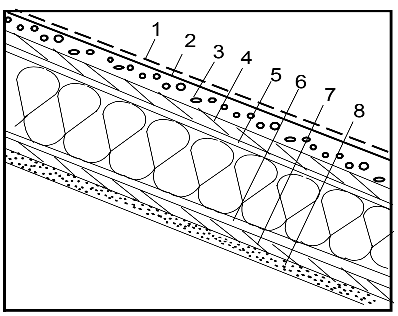
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.375 in plywood	0.470	0.470
4.	7/8 in furring channel	0.800	0.800
5.	2x4 in fir framing	-----	3.465
6.	3 5/8 in EPS foam insulation @3.85/inch	13.956	-----
7.	7/8 in furring channel	0.800	0.800
8.	0.375 in plywood	0.470	0.470
9.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	18.236	7.745
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/18.236}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{1-4/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/7.745}\right) \times \left(\underset{\text{Fr.\%}\div 100}{4/100}\right)\right] = \boxed{0.058}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.058} = 17.241\ \textbf{Total R-Value}$$

Reference Name: **RP.14.S2x4.48**



Sketch of Construction Assembly

Assembly Type: (check one)

____	Floor
____	Wall
✓	Ceiling/Roof

Framing Material: **Metal**

Framing Spacing: 48 "o.c.

Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	14.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

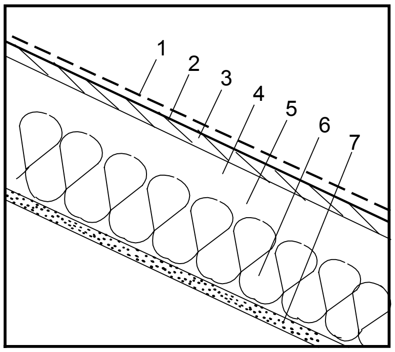
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper	0.060
3.	0.75 in polyisocyanurate	5.280
4.	3/8 in plywood	0.470
5.	7/8 in furring channel	0.800
6.	7/8 in furring channel	0.800
7.	3/8 in plywood	0.470
8.	1/2 in gypsum or plaster board	0.450
	Inside Surface Air Film	0.620

Calculation:

From EZFRAME = $\boxed{0.055}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.055} = 18.130\ \textbf{Total R-Value}$$

Reference Name: **R.19.2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- ______ Floor
- ______ Wall
- ✓ Ceiling/Roof

Framing Material: **Wood**

Framing Size: 2 × 8

Framing Spacing: 16 "o.c.

Framing (check one)

Wall:		15%
		12%
		9% (48"o.c.)
Floor/Ceilin	✓	10%
		7% (24"o.c.)
		4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

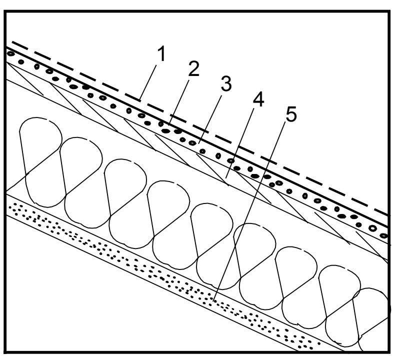
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	1.0 in air space; heat flow up	0.760	-----
5.	2x8 in fir framing	-----	7.178
6.	R-19 fiberglass insulation	19.000	-----
7.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	22.130	9.548
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1 \div R_c}{\underline{1/22.130}}\right) \times \left(\underset{1-(\text{Fr.\%} \div 100)}{\underline{1-10/100}}\right)\right] + \left[\left(\underset{1 \div R_f}{\underline{1/9.548}}\right) \times \left(\underset{\text{Fr.\%} \div 100}{\underline{10/100}}\right)\right] = \boxed{0.051} \text{ Total U-factor}$$

$$\underset{1 \div \text{Total U-factor}}{\underline{1/0.051}} = \underline{19.608} \text{ Total R-Value}$$

Reference Name: **R.19.S2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)
- ______ Floor
- ______ Wall
- ✓ Ceiling/Roof

Framing Material: **Metal**

Framing Spacing: 16 "o.c.

Framing Size:	Actual Depth	8.000
	Actual Width	1.625
Cavity Insulation:	R-value	19.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

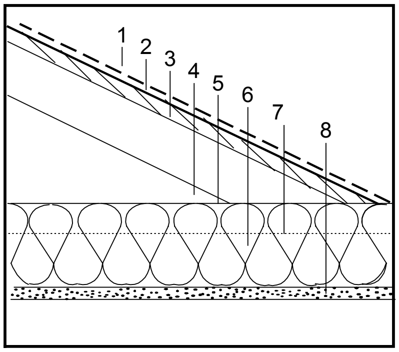
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building Paper	0.060
3.	1.25 in Polyisocyanurate	8.800
4.	0.5 in plywood	0.630
5.	0.50 in Gypsum board	0.450
6.		
7.		
	Inside Surface Air Film	0.620

Calculation:

From EZFRAME = $\boxed{0.051}$ **Total U-factor**

$$\underset{1 \div \text{Total U-factor}}{\underline{1/0.051}} = \underline{19.760} \text{ Total R-Value}$$

Reference Name: **R.19.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)

	Floor
	Wall
✓	Ceiling/Roof

Framing Material: Wood

Framing Size: 2 × 4

Framing Spacing: 24 "o.c.

Framing (check one)

Wall:		15%
		12%
		9% (48"o.c.)
Floor/Ceilin		10%
	✓	7% (24"o.c.)
		4% (48"o.c.)

Wall Weight / sf: NA
(Packages only)

List of Construction Components	**R-Value** Cavity (R_c)	Frame (R_f)
Outside Surface Air Film	0.170	0.170
1. Asphalt shingle roofing	0.440	0.440
2. Building paper (felt)	0.060	0.060
3. 0.50 in plywood	0.630	0.630
4. 3.50 in & greater air space; heat flow up	0.800	0.800
5. R-8 fiberglass insulation	8.000	8.000
6. R-11 fiberglass insulation	11.000	-----
7. 2x4 in fir framing	------	3.465
8. 0.50 in gypsum or plaster board	0.450	0.450
Inside Surface Air Film	0.610	0.610
Total Unadjusted R-Values:	22.160	14.625
	R_c	R_f

Framing Adjustment Calculation:

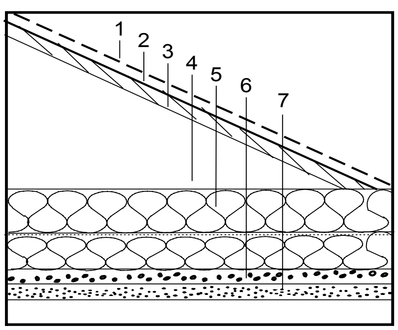
$$[(\underset{1 \div R_c}{1/22.160}) \times (\underset{1-(Fr.\% \div 100)}{1\text{-}7/100})] + [(\underset{1 \div R_f}{1/14.625}) \times (\underset{Fr.\% \div 100}{7/100})] = \boxed{0.047}$$

Total U-factor

$$\underset{1 \div \text{Total U-factor}}{1/0.047} = 21.277$$

Total R-Value

Reference Name: **R.19.S2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)

	Floor
	Wall
✓	Ceiling/Roof

Framing Material: Metal

Framing Spacing: 24 "o.c.

Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	11.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components	**R-Value**
Outside Surface Air Film	0.170
1. Asphalt shingle roofing	0.440
2. Building paper (felt)	0.060
3. 0.625 in Plywood	0.780
4. 3.5 in Air, Ceiling	0.800
5. R-8 fiberglass insulation	8.000
6. 0.75 in polyisocyanurate	5.280
7. 0.50 in Gypsum board	0.450
Inside Surface Air Film	0.610

Calculation:

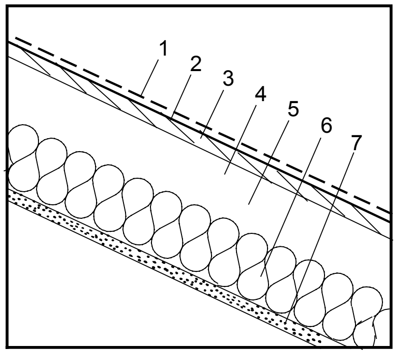
From EZFRAME = $\boxed{0.044}$

Total U-factor

$$\underset{1 \div \text{Total U-factor}}{1/0.044} = 22.670$$

Total R-Value

Reference Name: **R.22.2x10.16**



Sketch of Construction Assembly

Assembly Type: (check one)

	Floor
	Wall
✓	Ceiling/Roof

Framing Material: **Wood**

Framing Size: 2 × 10

Framing Spacing: 16 "o.c.

Framing (check one)

Wall:		15%
		12%
		9% (48"o.c.)
Floor/Ceilin	✓	10%
		7% (24"o.c.)
		4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.5" & greater air space; heat sideways	0.620	0.620
5.	2x10 in fir framing	-----	9.158
6.	R-22 fiberglass insulation	22.000	-----
7.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	24.990	12.148
		R_c	R_f

Framing Adjustment Calculation:

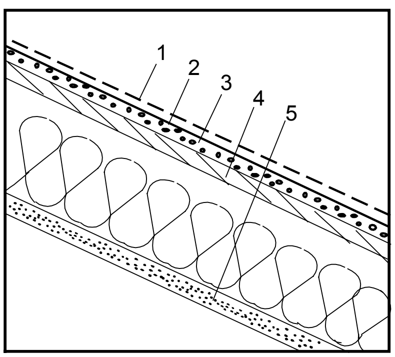
$$\left[\left(\underset{1\div R_c}{1/24.990}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{1-10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/12.148}\right) \times \left(\underset{\text{Fr.\%}\div 100}{10/100}\right)\right] = \boxed{0.044}$$

Total U-factor

$$\underset{1\div\text{Total U-factor}}{1/0.044} = 22.727$$

Total R-Value

Reference Name: **R.22.S2x10.16**



Sketch of Construction Assembly

Assembly Type: (check one)

	Floor
	Wall
✓	Ceiling/Roof

Framing Material: **Metal**

Framing Spacing: 16 "o.c.

Framing Size:	Actual Depth	10.000
	Actual Width	1.625
Cavity Insulation:	R-value	22.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	1.50 in polyisocyanurate	10.560
4.	0.50 in Plywood	0.630
5.	0.50 in gypsum or plaster board	0.450
6.		
7.		
	Inside Surface Air Film	0.620

Calculation:

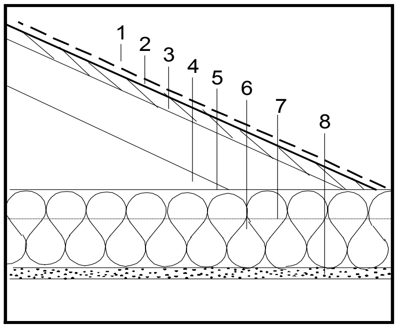
From EZFRAME = $\boxed{0.044}$

Total U-factor

$$\underset{1\div\text{Total U-factor}}{1/0.044} = 22.660$$

Total R-Value

Reference Name: **R.22.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 4	
Framing Spacing:	24 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin	10%
	✓	7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

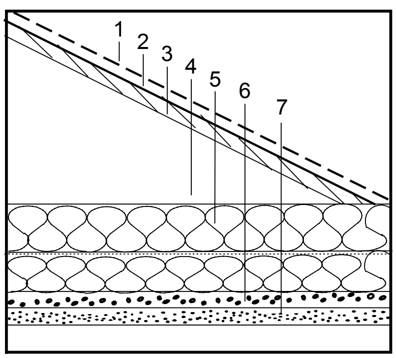
List of Construction Components	**R-Value** Cavity (R_c)	Frame (R_f)
Outside Surface Air Film	0.170	0.170
1. Asphalt shingle roofing	0.440	0.440
2. Building paper (felt)	0.060	0.060
3. 0.50 in plywood	0.630	0.630
4. 3.50 in & greater air space	0.800	0.800
5. R-11 fiberglass insulation	11.000	11.000
6. R-11 fiberglass insulation	11.000	-----
7. 2x4 in fir framing	-----	3.465
8. 0.50 in gypsum or plaster board	0.450	0.450
Inside Surface Air Film	0.610	0.610
Total Unadjusted R-Values:	25.160	17.625
	R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/25.160}\right) \times \left(\underset{1-(\text{Fr.}\% \div 100)}{1-7/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/17.625}\right) \times \left(\underset{\text{Fr.}\% \div 100}{7/100}\right)\right] = \boxed{0.041} \text{ Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.041} = 24.390 \text{ Total R-Value}$$

Reference Name: **R.22.S2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	24 "o.c.	
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	11.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

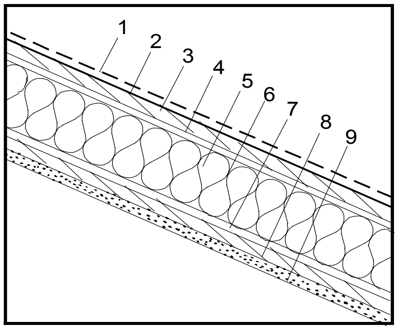
List of Construction Components	**R-Value**
Outside Surface Air Film	0.170
1. Asphalt shingle roofing	0.440
2. Building paper (felt)	0.060
3. 0.50 in plywood	0.630
4. 3.50 in & greater air space	0.800
5. R-11 fiberglass insulation	11.000
6. 0.75 in Polyisocyanurate	5.280
7. 0.50 in Gypsum Board	0.450
Inside Surface Air Film	0.610

Calculation:

From EZFRAME = $\boxed{0.039}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.039} = 25.500 \text{ Total R-Value}$$

Reference Name: **RP.22.2x6.48**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor	
		Wall	
	✓	Ceiling/Roof	
Framing Material:	Wood		
Framing Size:	2 × 6		
Framing Spacing:	48 "o.c.		
Framing (check one)	Wall:		15%
			12%
			9% (48"o.c.)
	Floor/Ceilin		10%
			7% (24"o.c.)
		✓	4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components | **R-Value**

	Component	Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.375 in plywood	0.470	0.470
4.	0.875 in furring channel	0.800	0.800
5.	5 5/8 in EPS foam insulation @ R-3.85/inch	21.656	-----
6.	2x6 in fir framing	-----	5.445
7.	0.875 in furring channel	0.800	0.800
8.	0.375 in plywood	0.470	0.470
9.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	25.936	9.725
		R_c	R_f

Framing Adjustment Calculation:

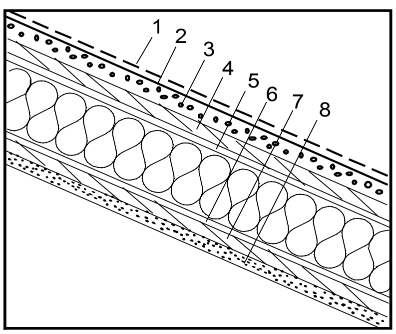
$$\left[\left(\underset{1\div R_c}{\underline{1/25.936}}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{\underline{1-4/100}}\right)\right] + \left[\left(\underset{1\div R_f}{\underline{1/9.725}}\right) \times \left(\underset{\text{Fr.\%}\div 100}{\underline{4/100}}\right)\right] = \boxed{0.041}$$

Total U-factor

$$\frac{1/0.041}{1\div\text{Total U-factor}} = 24.390$$

Total R-Value

Reference Name: **RP.22.S2x6.48**



Sketch of Construction Assembly

Assembly Type: (check one)			Floor
			Wall
		✓	Ceiling/Roof
Framing Material:	Metal		
Framing Spacing:	48 "o.c.		
Framing Size:	Actual Depth	6.000	
	Actual Width	1.625	
Cavity Insulation:	R-value	22.000	
	Knock-out (%)	15.000	
	Web	0.060	
Insulation Tape R-	Interior Flange		
	Exterior		

List of Construction Components | **R-Value**

	Component	R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	1.00 in polyisocyanurate	7.040
4.	0.375 in Plywood	0.470
5.	0.875 in furring channel	0.800
6.	0.875 in furring channel	0.800
7.	0.375 in Plywood	0.470
8.	0.50 in gypsum or plaster board	0.450
	Inside Surface Air Film	0.620

Calculation:

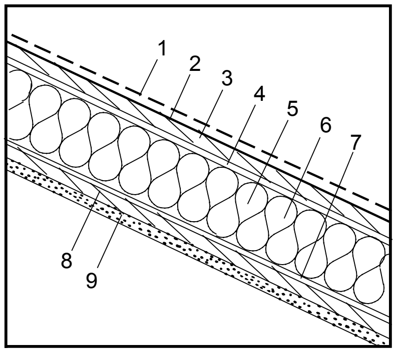
From EZFRAME = $\boxed{0.039}$

Total U-factor

$$\frac{1/0.039}{1\div\text{Total U-factor}} = 25.460$$

Total R-Value

Reference Name: **RP.28.2x8.48**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor	
		Wall	
	✓	Ceiling/Roof	
Framing Material:	**Wood**		
Framing Size:	2 × 8		
Framing Spacing:	48 "o.c.		
Framing (check one)	Wall:		15%
			12%
			9% (48"o.c.)
	Floor/Ceilin		10%
			7% (24"o.c.)
		✓	4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components

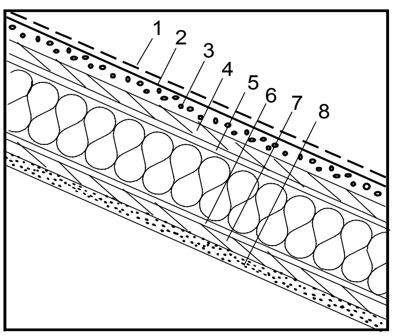
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.375 in plywood	0.470	0.470
4.	0.875 in furring channel	0.800	0.800
5.	7 3/8 in EPS foam insulation @ R-3.85/in	28.394	-----
6.	2x8 in fir framing	-----	7.178
7.	0.875 in furring channel	0.800	0.800
8.	0.375 in plywood	0.470	0.470
9.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	32.674	11.458
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/32.674}\right) \times \left(\underset{1-(\text{Fr.}\% \div 100)}{1-4/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/11.458}\right) \times \left(\underset{\text{Fr.}\% \div 100}{4/100}\right)\right] = \boxed{0.033}\ \textbf{Total U-factor}$$

$$\underset{1\div \text{Total U-factor}}{1/0.033} = 30.303\ \textbf{Total R-Value}$$

Reference Name: **RP.28.S2x8.48**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	48 "o.c.	
Framing Size:	Actual Depth	8.000
	Actual Width	1.625
Cavity Insulation:	R-value	28.394
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

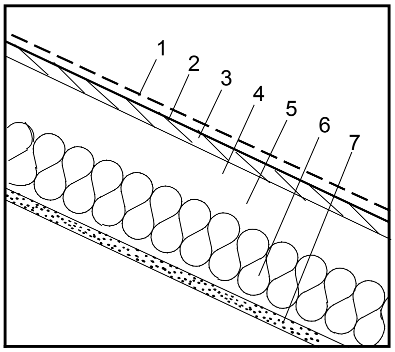
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	1.75 in polyisocyanurate	12.320
4.	0.375 in Plywood	0.470
5.	0.875 in furring channel	0.800
6.	0.875 in furring channel	0.800
7.	0.375 in Plywood	0.470
8.	0.50 in gypsum or plaster board	0.450
	Inside Surface Air Film	0.620

Calculation:

From EZFRAME = $\boxed{0.031}$ **Total U-factor**

$$\underset{1\div \text{Total U-factor}}{1/0.031} = 31.940\ \textbf{Total R-Value}$$

Reference Name: **R.30.2x12.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	Wood	
Framing Size:	2 × 12	
Framing Spacing:	16 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin ✓	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	1.75 in air space; heat fow up	0.780	-----
5.	2x12 in fir framing	-----	11.138
6.	R-30 fiberglass insulation	30.000	-----
7.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	33.150	13.508
		R_c	R_f

Framing Adjustment Calculation:

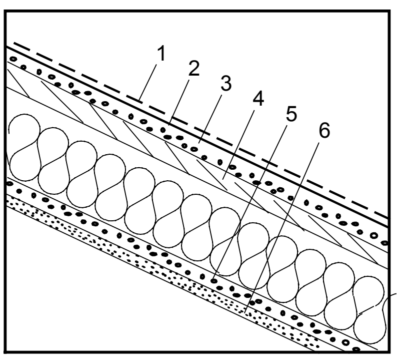
$$\left[\left(\underset{1\div R_c}{1/33.150}\right) \times \left(\underset{1-(Fr.\%\div100)}{1-10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/13.508}\right) \times \left(\underset{Fr.\%\div100}{10/100}\right)\right] = \boxed{0.035}$$

Total U-factor

$$\frac{1/0.035}{1\div\text{Total U-factor}} = 28.571$$

Total R-Value

Reference Name: **R.30.S2x12.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	Metal	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	12.000
	Actual Width	1.625
Cavity Insulation:	R-value	30.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building Paper	0.060
3.	1.50 in Polyisocyanurate	10.56
4.	0.50 in plywood	0.630
5.	1.00 in Polyisocyanurate	7.04
6.	0.50 in gypsum or plaster board	0.450
7.		
	Inside Surface Air Film	0.620

Calculation:

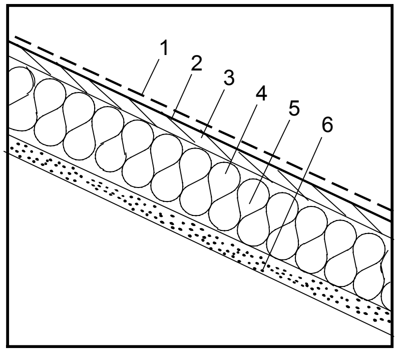
From EZFRAME = $\boxed{0.032}$

Total U-factor

$$\frac{1/0.032}{1\div\text{Total U-factor}} = 31.64$$

Total R-Value

Reference Name: **R.30.2x10.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 10	
Framing Spacing:	16 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin ✓	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

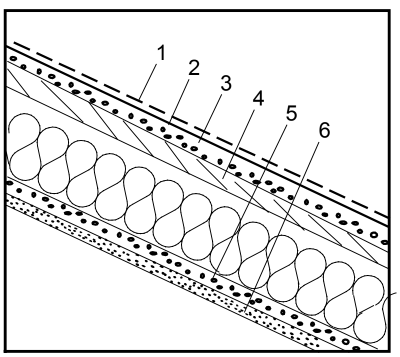
List of Construction Components		**R-Value** Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	2x10 in fir framing	-----	9.158
5.	R-30 fiberglass insulation (8.5'' thkns)	30.000	-----
6.	0.50 in gypsum or plaster board	0.450	0.450
7.			
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	32.370	11.528
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/32.370}\right) \times \left(\underset{1\text{-(Fr.\% }\div 100)}{1\text{-}10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/11.528}\right) \times \left(\underset{\text{Fr.\% }\div 100}{10/100}\right)\right] = \boxed{0.036}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.036} = 27.778\ \textbf{Total R-Value}$$

Reference Name: **R.30.S2x10.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	10.000
	Actual Width	1.625
Cavity Insulation:	R-value	30.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

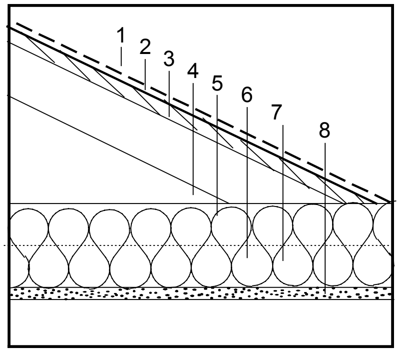
List of Construction Components		**R-Value**
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building Paper	0.060
3.	1.50 in Polyisocyanurate	10.560
4.	0.50 in plywood	0.630
5.	0.75 in Polyisocyanurate	5.280
6.	0.50 in gypsum or plaster board	0.450
7.		
	Inside Surface Air Film	0.620

Calculation:

From EZFRAME = $\boxed{0.034}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.034} = 29.220\ \textbf{Total R-Value}$$

Reference Name: **R.30.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	Wood	
Framing Size:	2 × 4	
Framing Spacing:	24 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin	10%
	✓	7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

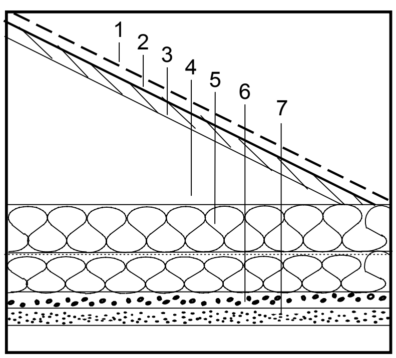
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.50 in & greater air space	0.800	0.800
5.	R-19 fiberglass insulation	19.000	19.000
6.	R-11 fiberglass insulation	11.000	-----
7.	2X4 in fir framing	-----	3.465
8.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.610	0.610
	Total Unadjusted R-Values:	33.160	25.625
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/33.160}\right) \times \left(\underset{1-(\text{Fr.}\% \div 100)}{1-7/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/25.625}\right) \times \left(\underset{\text{Fr.}\% \div 100}{7/100}\right)\right] = \boxed{0.031}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.031} = 32.258\ \textbf{Total R-Value}$$

Reference Name: **R.30.S2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	Metal	
Framing Spacing:	24 "o.c.	
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	11.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

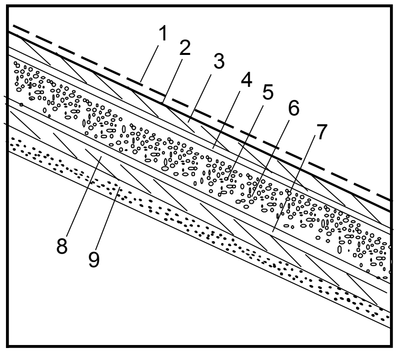
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	0.50 in plywood	0.630
4.	3.50 in & greater air space	0.800
5.	R-19 fiberglass insulation	19.000
6.	0.75 in Polyisocyanurate	5.280
7.	0.50 in Gypsum Board	0.450
	Inside Surface Air Film	0.610

Calculation:

From EZFRAME = $\boxed{0.030}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.030} = 33.52\ \textbf{Total R-Value}$$

Reference Name: **RP.35.2x10.48**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 10	
Framing Spacing:	48 “o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48”o.c.)
	Floor/Ceilin	10%
		7% (24”o.c.)
	✓	4% (48”o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.375 in plywood	0.470	0.470
4.	0.875 furring channel	0.800	0.800
5.	4 in EPS foam insulation	35.000	-----
6.	2x10 in fir framing	-----	9.158
7.	0.875 furring channel	0.800	0.800
8.	0.375 in plywood	0.470	0.470
9.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	39.280	13.438
		R_c	R_f

Framing Adjustment Calculation:

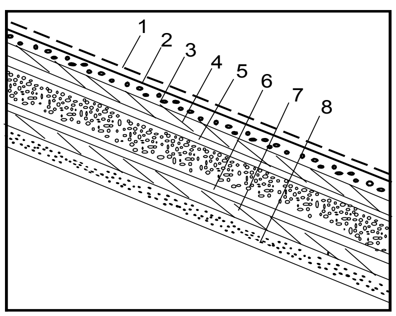
$$\left[\left(\underset{1 \div R_c}{1/39.280}\right) \times \left(\underset{1-(\text{Fr.}\% \div 100)}{1-4/100}\right)\right] + \left[\left(\underset{1 \div R_f}{1/13.438}\right) \times \left(\underset{\text{Fr.}\% \div 100}{4/100}\right)\right] = \boxed{0.027}$$

Total U-factor

$$\underset{1 \div \text{Total U-factor}}{1/0.027} = 37.037$$

Total R-Value

Reference Name: **RP.35.S2x10.48**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	48 “o.c.	
Framing Size:	Actual Depth	10.000
	Actual Width	1.625
Cavity Insulation:	R-value	35.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	2.25 in polyisocyanurate	15.840
4.	0.375 in plywood	0.470
5.	0.875 in furring channel	0.800
6.	0.875 in furring channel	0.800
7.	0.375 in plywood	0.470
8.	0.50 in gypsum or plaster board	0.450
	Inside Surface Air Film	0.620

Calculation:

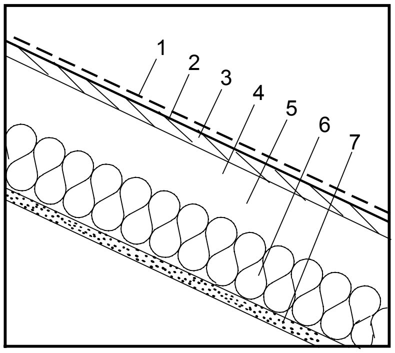
From EZFRAME = $\boxed{0.026}$

Total U-factor

$$\underset{1 \div \text{Total U-factor}}{1/0.026} = 38.44$$

Total R-Value

Reference Name: **R.38.2x14.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 14	
Framing Spacing:	16 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin ✓	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components	**R-Value** Cavity (R_c)	Frame (R_f)
Outside Surface Air Film	0.170	0.170
1. Asphalt shingle roofing	0.440	0.440
2. Building paper (felt)	0.060	0.060
3. 0.50 in plywood	0.630	0.630
4. 1.25 in air space; heat flow up	0.760	-----
5. 2x14 in fir framing	-----	13.118
6. R-38 fiberglass insulation	38.000	-----
7. 0.50 in gypsum or plaster board	0.450	0.450
Inside Surface Air Film	0.620	0.620
Total Unadjusted R-Values:	41.130	15.488
	R_c	R_f

Framing Adjustment Calculation:

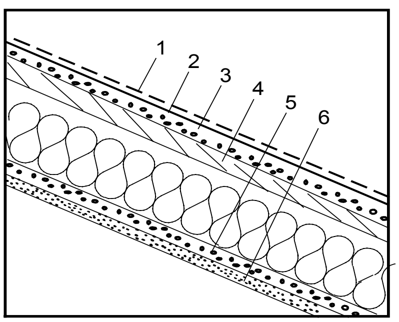
$$\left[\left(\underset{1\div R_c}{1/41.130}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{1-10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/15.488}\right) \times \left(\underset{\text{Fr.\%}\div 100}{10/100}\right)\right] = \boxed{0.028}$$

Total U-factor

$$\underset{1\div\text{Total U-factor}}{1/0.028} = 35.714$$

Total R-Value

Reference Name: **R.38.S2x14.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	14.000
	Actual Width	1.625
Cavity Insulation:	R-value	38.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components	**R-Value**
Outside Surface Air Film	0.170
1. Asphalt shingle roofing	0.440
2. Building paper (felt)	0.060
3. 1.50 in Polyisocyanurate	10.560
4. 0.50 in Plywood	0.630
5. 1.50 in Polyisocyanurate	10.560
6. 0.50 in gypsum or plaster board	0.450
7.	
Inside Surface Air Film	0.620

Calculation:

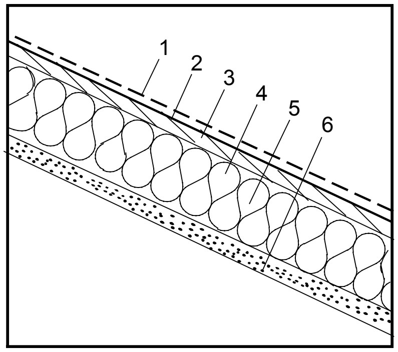
From EZFRAME = $\boxed{0.027}$

Total U-factor

$$\underset{1\div\text{Total U-factor}}{1/0.027} = 36.95$$

Total R-Value

Reference Name: **R.38.2x12.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 12	
Framing Spacing:	16 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin ✓	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components / **R-Value**

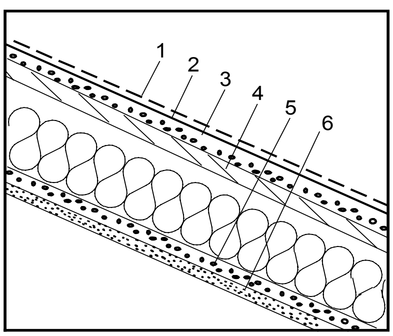
		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	2x12 in fir framing	-----	11.138
5.	R-38 fiberglass insulation	38.000	-----
6.	0.50 in gypsum or plaster board	0.450	0.450
7.			
	Inside Surface Air Film	0.620	0.620
	Total Unadjusted R-Values:	40.370	13.508
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/40.370}\right) \times \left(\underset{1-(\text{Fr.\%} \div 100)}{1-10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/13.508}\right) \times \left(\underset{\text{Fr.\%} \div 100}{10/100}\right)\right] = \boxed{0.030}\ \textbf{Total U-factor}$$

$$\frac{1/0.030}{1\div\text{Total U-factor}} = 33.333\ \textbf{Total R-Value}$$

Reference Name: **R.38.S2x12.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor
		Wall
	✓	Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	12.000
	Actual Width	1.625
Cavity Insulation:	R-value	38.800
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components / **R-Value**

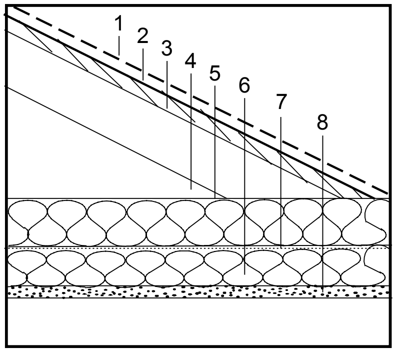
		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	1.50 in polyisocyanurate	10.560
4.	0.625 in plywood	0.780
5.	1.00 in polyisocyanurate	7.040
6.	0.625 in gypsum or plaster board	0.560
7.		
	Inside Surface Air Film	0.620

Calculation:

From EZFRAME = $\boxed{0.030}$ **Total U-factor**

$$\frac{1/0.030}{1\div\text{Total U-factor}} = 33.38\ \textbf{Total R-Value}$$

Reference Name: **R.38.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor	
		Wall	
	✓	Ceiling/Roof	
Framing Material:	**Wood**		
Framing Size:	2 × 4		
Framing Spacing:	24 "o.c.		
Framing (check one)	Wall:		15%
			12%
			9% (48"o.c.)
	Floor/Ceilin		10%
		✓	7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components

		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.50 in & greater air space: heat flow up	0.800	0.800
5.	R-27 fiberglass insulation	27.000	27.000
6.	R-11 fiberglass insulation	11.000	-----
7.	2x4 in fir framing	-----	3.465
8.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.610	0.610
	Total Unadjusted R-Values:	41.160	33.625
		R_c	R_f

Framing Adjustment Calculation:

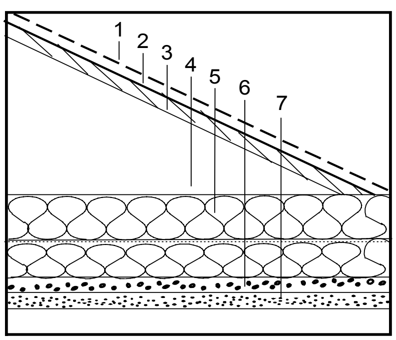
$$\left[\left(\underset{1\div R_c}{1/41.160}\right) \times \left(\underset{1-(Fr.\% \div 100)}{1-7/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/33.625}\right) \times \left(\underset{Fr.\% \div 100}{7/100}\right)\right] = \boxed{0.025}$$

Total U-factor

$$\underset{1\div \text{Total U-factor}}{1/0.025} = 40.000$$

Total R-Value

Reference Name: **R.38.S2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor	
		Wall	
	✓	Ceiling/Roof	
Framing Material:	**Metal**		
Framing Spacing:	24 "o.c.		
Framing Size:		Actual Depth	3.625
		Actual Width	1.625
Cavity Insulation:		R-value	11.000
		Knock-out (%)	15.000
		Web	0.060
Insulation Tape R-		Interior Flange	
		Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	0.50 in Plywood	0.630
4.	3.50 in & greater air space: heat flow up	0.800
5.	R-27 fiberglass insulation	27.000
6.	1.00 in polyisocyanurate	7.040
7.	0.50 in gypsum or plaster board	0.450
	Inside Surface Air Film	0.610

Calculation:

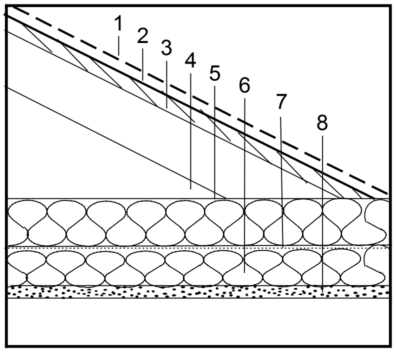
From EZFRAME = $\boxed{0.023}$

Total U-factor

$$\underset{1\div \text{Total U-factor}}{1/0.023} = 43.25$$

Total R-Value

Reference Name: **R.49.2x4.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor	
		Wall	
	✓	Ceiling/Roof	
Framing Material:	Wood		
Framing Size:	2 × 4		
Framing Spacing:	16 "o.c.		
Framing (check one)	Wall:		15%
			12%
			9% (48"o.c.)
	Floor/Ceilin	✓	10%
			7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components

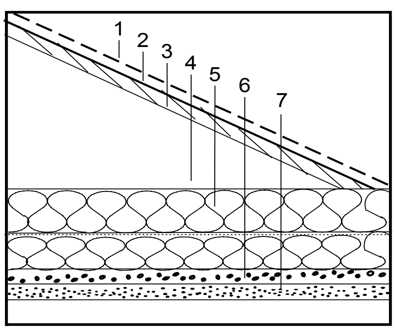
	List of Construction Components	R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.50 in & greater air space: heat flow up	0.800	0.800
5.	R-38 fiberglass insulation	38.000	38.000
6.	R-11 fiberglass insulation	11.000	-----
7.	2x4 in fir framing	-----	3.465
8.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.610	0.610
	Total Unadjusted R-Values:	52.160	44.625
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\frac{1/52.160}{1\div R_c}\right) \times \left(\frac{1-10/100}{1-(\text{Fr.}\% \div 100)}\right)\right] + \left[\left(\frac{1/44.625}{1\div R_f}\right) \times \left(\frac{10/100}{\text{Fr.}\% \div 100}\right)\right] = \boxed{0.019} \text{ Total U-factor}$$

$$\frac{1/0.019}{1\div \text{Total U-factor}} = 52.632 \text{ Total R-Value}$$

Reference Name: **R.49.S2x4.16**



Sketch of Construction Assembly

Assembly Type: (check one)		Floor	
		Wall	
	✓	Ceiling/Roof	
Framing Material:	Metal		
Framing Spacing:	16 "o.c.		
Framing Size:		Actual Depth	3.625
		Actual Width	1.625
Cavity Insulation:		R-value	11.000
		Knock-out (%)	15.000
		Web	0.060
Insulation Tape R-		Interior Flange	
		Exterior	

List of Construction Components

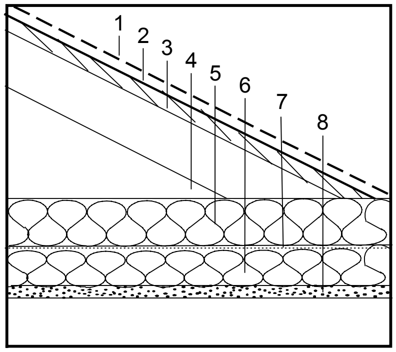
	List of Construction Components	R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	0.50 in plywood	0.630
4.	3.50 in air space	0.800
5.	R-38 fiberglass insulation	38.000
6.	1.00 in polyisocyanurate	7.040
7.	0.50 in gypsum or plaster board	0.450
	Inside Surface Air Film	0.610

Calculation:

From EZFRAME = $\boxed{0.019}$ **Total U-factor**

$$\frac{1/0.019}{1\div \text{Total U-factor}} = 53.02 \text{ Total R-Value}$$

Reference Name: **R.49.2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)	____	Floor
	____	Wall
	✓	Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 4	
Framing Spacing:	24 “o.c.	
Framing (check one)	Wall: ____	15%
	____	12%
	____	9% (48”o.c.)
	Floor/Ceilin ____	10%
	✓	7% (24”o.c.)
	____	4% (48”o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

	List of Construction Components	R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Asphalt shingle roofing	0.440	0.440
2.	Building paper (felt)	0.060	0.060
3.	0.50 in plywood	0.630	0.630
4.	3.50 in & greater air space; heat flow up	0.800	0.800
5.	R-38 fiberglass insulation	38.000	38.000
6.	R-11 fiberglass insulation	11.000	-----
7.	2x4 in fir framing	-----	3.465
8.	0.50 in gypsum or plaster board	0.450	0.450
	Inside Surface Air Film	0.610	0.610
	Total Unadjusted R-Values:	52.160	44.625
		R_c	R_f

Framing Adjustment Calculation:

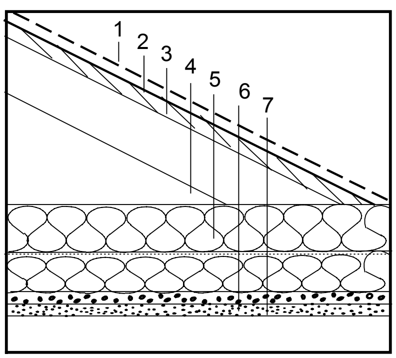
$$\left[\left(\underset{1\div R_c}{1/52.160}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{1-7/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/44.625}\right) \times \left(\underset{\text{Fr.\%}\div 100}{7/100}\right)\right] = \boxed{0.019}$$

Total U-factor

$$\frac{1/0.019}{1\div\text{Total U-factor}} = 52.632$$

Total R-Value

Reference Name: **R.49.S2x4.24**



Sketch of Construction Assembly

Assembly Type: (check one)	____	Floor
	____	Wall
	✓	Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	24 “o.c.	
Framing Size:	Actual Depth	3.625
	Actual Width	1.625
Cavity Insulation:	R-value	11.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

	List of Construction Components	R-Value
	Outside Surface Air Film	0.170
1.	Asphalt shingle roofing	0.440
2.	Building paper (felt)	0.060
3.	0.50 in Plywood	0.630
4.	3.50 in & greater air space; heat flow up	0.800
5.	R-38 fiberglass insulation	38.000
6.	0.25 in Polyisocyanurate	1.760
7.	0.75 in gypsum or plaster board	0.680
	Inside Surface Air Film	0.610

Calculation:

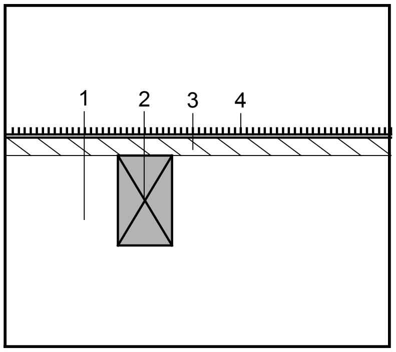
From EZFRAME = $\boxed{0.018}$

Total U-factor

$$\frac{1/0.018}{1\div\text{Total U-factor}} = 54.250$$

Total R-Value

Reference Name: **FC.0.2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 6	
Framing Spacing:	16 “o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48”o.c.)
	Floor/Ceilin ✓	10%
		7% (24”o.c.)
		4% (48”o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Effective R-value of vented crawlspace	6.000	6.000
2.	2x6 in fir framing	-----	5.445
3.	0.625 in plywood	0.780	0.780
4.	Carpet & Pad	2.080	2.080
5.			
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	9.950	15.395
		R_c	R_f

R-Value

Framing Adjustment Calculation:

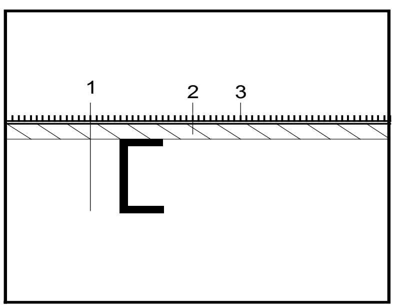
$$\left[\left(\frac{1/9.950}{1 \div R_c}\right) \times \left(\frac{1-10/100}{1-(\text{Fr.}\% \div 100)}\right)\right] + \left[\left(\frac{1/15.395}{1 \div R_f}\right) \times \left(\frac{10/100}{\text{Fr.}\% \div 100}\right)\right] = \boxed{0.097}$$

Total U-factor

$$\frac{1/0.097}{1 \div \text{Total U-factor}} = 10.309$$

Total R-Value

Reference Name: **FC.0.S2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 “o.c.	
Framing Size:	Actual Depth	6.000
	Actual Width	1.625
Cavity Insulation:	R-value	0.800
	Knock-out (%)	15.000
Insulation Tape R-	Web	0.060
	Interior Flange	
	Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	Effective R-value of vented crawlspace	6.000
2.	0.625 in plywood	0.780
3.	Carpet & Pad	2.080
4.		
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

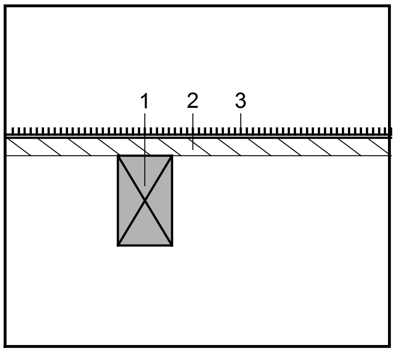
From EZFRAME = $\boxed{0.094}$

Total U-factor

$$\frac{1/0.094}{1 \div \text{Total U-factor}} = 10.680$$

Total R-Value

Reference Name: **FX.0.2x6.16**



Sketch of Construction Assembly

Assembly Type:	✓	Floor	
(check one)		Wall	
		Ceiling/Roof	
Framing Material:	**Wood**		
Framing Size:	2 × 6		
Framing Spacing:	16 “o.c.		
Framing	Wall:		15%
(check one)			12%
			9% (48”o.c.)
	Floor/Ceilin	✓	10%
			7% (24”o.c.)
			4% (48”o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components

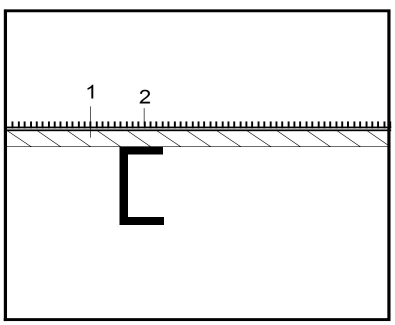
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	2x6 in fir framing	-----	5.445
2.	0.625 in plywood	0.780	0.780
3.	Carpet & Pad	2.080	2.080
4.			
5.			
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	3.950	9.395
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/3.950}\right) \times \left(\underset{1-(\text{Fr.}\% \div 100)}{1-10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/9.395}\right) \times \left(\underset{\text{Fr.}\% \div 100}{10/100}\right)\right] = \boxed{0.238}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.238} = \underset{\textbf{Total R-Value}}{4.202}$$

Reference Name: **FX.0.S2x6.16**



Sketch of Construction Assembly

Assembly Type:	✓	Floor	
(check one)		Wall	
		Ceiling/Roof	
Framing Material:	**Metal**		
Framing Spacing:	16 “o.c.		
Framing Size:		Actual Depth	6.000
		Actual Width	1.625
Cavity Insulation:		R-value	0.800
		Knock-out (%)	15.000
		Web	0.060
Insulation Tape R-		Interior Flange	
		Exterior	

List of Construction Components

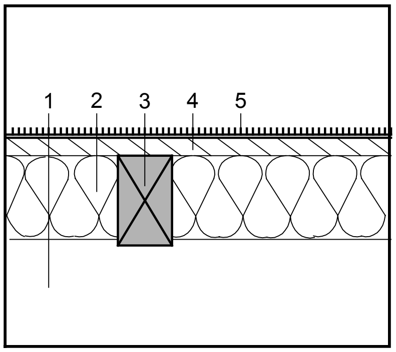
		R-Value
	Outside Surface Air Film	0.170
1.	0.625 in plywood	0.780
2.	Carpet & pad	2.080
3.		
4.		
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

From EZFRAME = $\boxed{0.253}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.253} = \underset{\textbf{Total R-Value}}{3.950}$$

Reference Name: **FC.11.2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one) ✓ Floor; Wall; Ceiling/Roof

Framing Material: Wood

Framing Size: 2 × 6

Framing Spacing: 16 "o.c.

Framing (check one)

Wall:		15%
		12%
		9% (48"o.c.)
Floor/Ceilin	✓	10%
		7% (24"o.c.)
		4% (48"o.c.)

Wall Weight / sf: (Packages only) NA

List of Construction Components

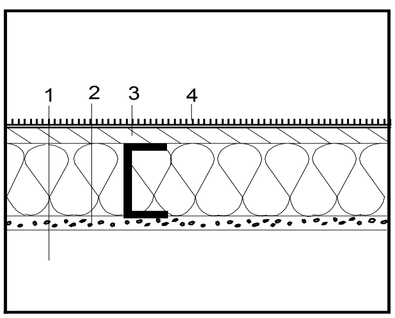
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Effective R-value of vented crawlspace	6.000	6.000
2.	R-11 fiberglass insulation	11.000	-----
3.	2x6 in fir framing	-----	5.445
4.	0.625 in plywood	0.780	0.780
5.	Carpet & pad	2.080	2.080
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	20.950	15.395
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\frac{1/20.950}{1\div R_c}\right) \times \left(\frac{1-10/100}{1-(\text{Fr.}\%\div 100)}\right)\right] + \left[\left(\frac{1/15.395}{1\div R_f}\right) \times \left(\frac{10/100}{\text{Fr.}\%\div 100}\right)\right] = \boxed{0.049}\ \textbf{Total U-factor}$$

$$\frac{1/0.049}{1\div\text{Total U-factor}} = 20.408\ \textbf{Total R-Value}$$

Reference Name: **FC.11.S2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one) ✓ Floor; Wall; Ceiling/Roof

Framing Material: Metal

Framing Spacing: 16 "o.c.

Framing Size:	Actual Depth	6.000
	Actual Width	1.625
Cavity Insulation:	R-value	11.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

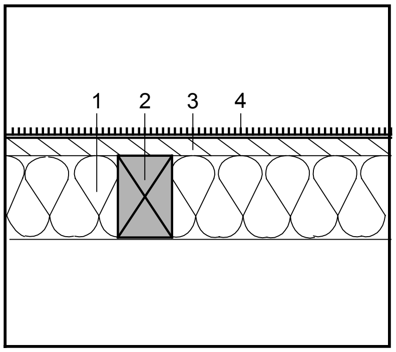
		R-Value
	Outside Surface Air Film	0.170
1.	Effective R-value of vented crawlspace	6.000
2.	0.75 in polyisocyanurate	5.280
3.	0.625 in plywood	0.780
4.	Carpet & pad	2.080
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

From EZFRAME = $\boxed{0.048}$ **Total U-factor**

$$\frac{1/0.048}{1\div\text{Total U-factor}} = 21.030\ \textbf{Total R-Value}$$

Reference Name: **FX.11.2x6.16**



Sketch of Construction Assembly

Assembly Type:	✓	Floor	
(check one)		Wall	
		Ceiling/Roof	
Framing Material:	**Wood**		
Framing Size:	2 × 6		
Framing Spacing:	16 "o.c.		
Framing	Wall:		15%
(check one)			12%
			9% (48"o.c.)
	Floor/Ceilin	✓	10%
			7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components / **R-Value**

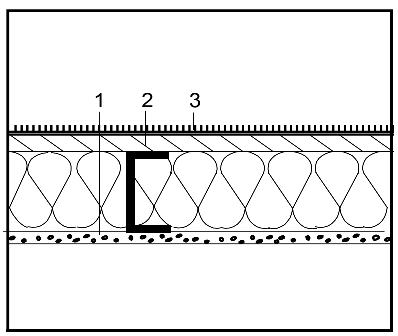
		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	R-11 fiberglass insulation	11.000	-----
2.	2x6 in fir framing	-----	5.445
3.	0.625 in plywood	0.780	0.780
4.	Carpet & pad	2.080	2.080
5.			
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	14.940	9.395
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underbrace{1/14.950}_{1\div R_c}\right) \times \left(\underbrace{1\text{-}10/100}_{1\text{-}(\text{Fr.}\% \div 100)}\right)\right] + \left[\left(\underbrace{1/9.395}_{1\div R_f}\right) \times \left(\underbrace{10/100}_{\text{Fr.}\% \div 100}\right)\right] = \underbrace{\boxed{0.071}}_{\textbf{Total U-factor}}$$

$$\underbrace{1/0.071}_{1\div\text{Total U-factor}} = \underbrace{14.085}_{\textbf{Total R-Value}}$$

Reference Name: **FX.11.S2x6.16**



Sketch of Construction Assembly

Assembly Type:	✓	Floor
(check one)		Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	6.000
	Actual Width	1.625
Cavity Insulation:	R-value	11.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components / **R-Value**

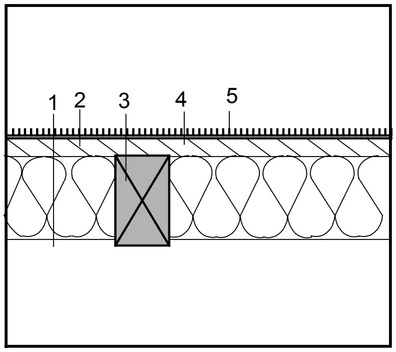
		R-Value
	Outside Surface Air Film	0.170
1.	0.75 in polyisocyanurate	5.280
2.	0.625 in plywood	0.780
3.	Carpert & pad	2.080
4.		
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

From EZFRAME = $\boxed{0.071}$ **Total U-factor**

$$\underbrace{1/0.071}_{1\div\text{Total U-factor}} = \underbrace{14.16}_{\textbf{Total R-Value}}$$

Reference Name: **FC.13.2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor	
		Wall	
		Ceiling/Roof	
Framing Material:	**Wood**		
Framing Size:	2 × 6		
Framing Spacing:	16 "o.c.		
Framing (check one)	Wall:		15%
			12%
			9% (48"o.c.)
	Floor/Ceilin	✓	10%
			7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components

		R-Value Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Effective R-Value of vented crawlspace	6.000	6.000
2.	R-13 fiberglass insulation	13.000	-----
3.	2x6 in fir framing	-----	5.445
4.	0.625 in plywood	0.780	0.780
5.	Carpet & pad	2.080	2.080
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	22.950	15.395
		R_c	R_f

Framing Adjustment Calculation:

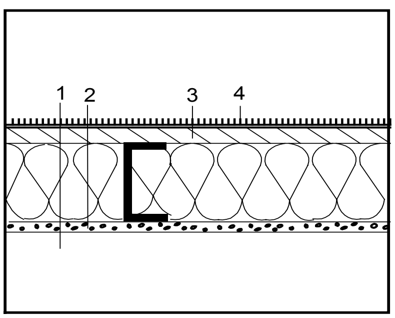
$$\left[\left(\frac{1/22.950}{1 \div R_c}\right) \times \left(\frac{1-10/100}{1-(\text{Fr.\%} \div 100)}\right)\right] + \left[\left(\frac{1/15.395}{1 \div R_f}\right) \times \left(\frac{10/100}{\text{Fr.\%} \div 100}\right)\right] = \boxed{0.046}$$

Total U-factor

$$\frac{1/0.046}{1 \div \text{Total U-factor}} = 21.740$$

Total R-Value

Reference Name: **FC.13.S2x6.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor	
		Wall	
		Ceiling/Roof	
Framing Material:	**Metal**		
Framing Spacing:	16 "o.c.		
Framing Size:		Actual Depth	6.000
		Actual Width	1.625
Cavity Insulation:		R-value	13.000
		Knock-out (%)	15.000
		Web	0.060
Insulation Tape R-		Interior Flange	
		Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	Effective R-Value of vented crawlspace	6.000
2.	1.00 in polyisocyanurate	7.040
3.	0.625 in plywood	0.780
4.	Carpet & pad	2.080
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

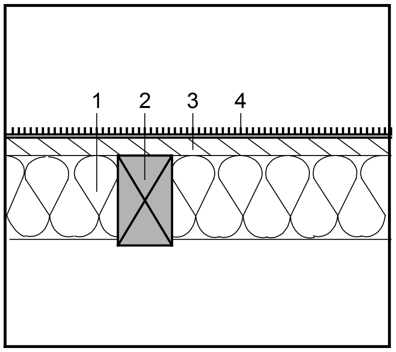
From EZFRAME = $\boxed{0.043}$

Total U-factor

$$\frac{1/0.043}{1 \div \text{Total U-factor}} = 23.340$$

Total R-Value

Reference Name: **FX.13.2x6.16**



Sketch of Construction Assembly

Assembly Type:	✓	Floor	
(check one)		Wall	
		Ceiling/Roof	
Framing Material:	**Wood**		
Framing Size:	2 × 6		
Framing Spacing:	16 "o.c.		
Framing (check one)	Wall:		15%
			12%
			9% (48"o.c.)
	Floor/Ceilin	✓	10%
			7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components

		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	R-13 fiberglass insulation	13.000	-----
2.	2x6 in fir framing	-----	5.445
3.	0.625 in plywood	0.780	0.780
4.	Carpet & pad	2.080	2.080
5.			
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	16.950	9.395
		R_c	R_f

Framing Adjustment Calculation:

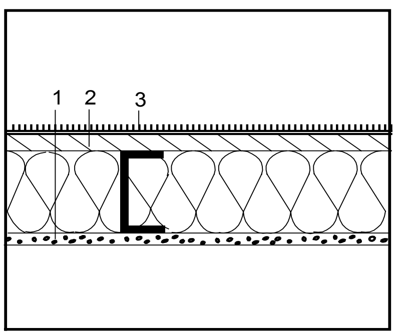
$$\left[\left(\underset{1 \div R_c}{\underline{1/16.950}}\right) \times \left(\underset{1\text{-(Fr.\% } \div 100)}{\underline{1\text{-}10/100}}\right)\right] + \left[\left(\underset{1 \div R_f}{\underline{1/9.395}}\right) \times \left(\underset{\text{Fr.\% } \div 100}{\underline{10/100}}\right)\right] = \boxed{0.064}$$

Total U-factor

$$\underset{1 \div \text{Total U-factor}}{\underline{1/0.064}} = 15.625$$

Total R-Value

Reference Name: **FX.13.S2x6.16**



Sketch of Construction Assembly

Assembly Type:	✓	Floor
(check one)		Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	6.000
	Actual Width	1.625
Cavity Insulation:	R-value	13.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	1.00 in polyisocyanurate	7.040
2.	0.625 in plywood	0.780
3.	Carpet & pad	2.080
4.		
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

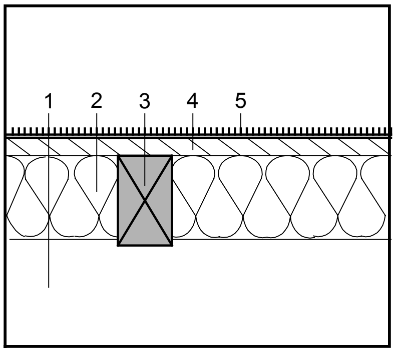
From EZFRAME = $\boxed{0.058}$

Total U-factor

$$\underset{1 \div \text{Total U-factor}}{\underline{1/0.058}} = 17.340$$

Total R-Value

Reference Name: **FC.19.2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 8	
Framing Spacing:	16 “o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48”o.c.)
	Floor/Ceilin ✓	10%
		7% (24”o.c.)
		4% (48”o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Effective R-value of vented crawlspace	6.000	6.000
2.	R-19 fiberglass insulation	19.000	-----
3.	7.25 in fir framing	-----	7.178
4.	0.625 in plywood	0.780	0.780
5.	Carpet & pad	2.080	2.080
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	28.950	17.128
		R_c	R_f

Framing Adjustment Calculation:

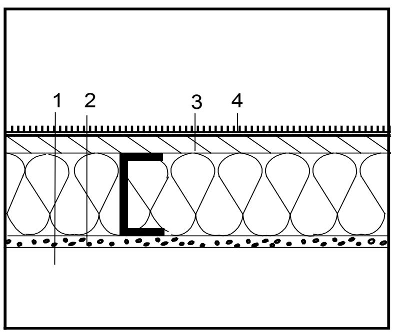
$$\left[\left(\frac{1/28.950}{1 \div R_c}\right) \times \left(\frac{1-10/100}{1-(\text{Fr.}\% \div 100)}\right)\right] + \left[\left(\frac{1/17.128}{1 \div R_f}\right) \times \left(\frac{10/100}{\text{Fr.}\% \div 100}\right)\right] = \boxed{0.037}$$

Total U-factor

$$\frac{1/0.037}{1 \div \text{Total U-factor}} = 27.027$$

Total R-Value

Reference Name: **FC.19.S2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 “o.c.	
Framing Size:	Actual Depth	8.00
	Actual Width	1.625
Cavity Insulation:	R-value	19.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

		R-Value
	Outside Surface Air Film	0.170
1.	Effective R-value of vented crawlspace	6.000
2.	1.50 in polyisocyanurate	10.560
3.	0.625 in plywood	0.780
4.	Carpet & pad	2.080
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

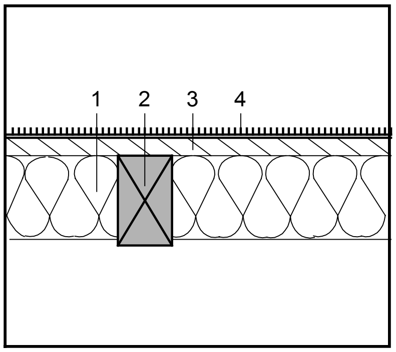
From EZFRAME = $\boxed{0.035}$

Total U-factor

$$\frac{1/0.035}{1 \div \text{Total U-factor}} = 28.700$$

Total R-Value

Reference Name: **FX.19.2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 8	
Framing Spacing:	16 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin ✓	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

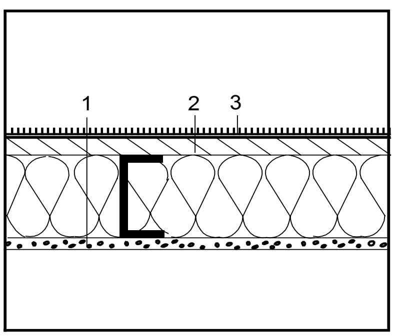
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	R-19 fiberglass insulation	19.000	-----
2.	7.25 in fir framing	-----	7.178
3.	0.625 in plywood	0.780	0.780
4.	Carpet & pad	2.080	2.080
5.			
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	22.950	11.128
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/22.950}\right) \times \left(\underset{1-(\mathrm{Fr.}\%\div 100)}{1-10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/11.128}\right) \times \left(\underset{\mathrm{Fr.}\%\div 100}{10/100}\right)\right] = \boxed{0.049}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.049} = \underset{\textbf{Total R-Value}}{20.408}$$

Reference Name: **FX.19.S2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	8.000
	Actual Width	1.625
Cavity Insulation:	R-value	19.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

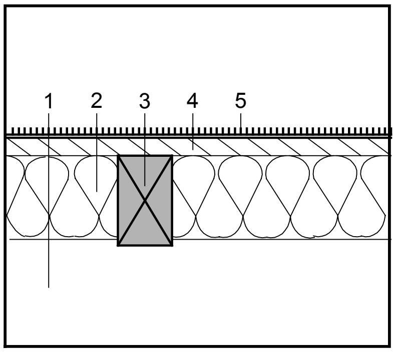
		R-Value
	Outside Surface Air Film	0.170
1.	1.25 in polyisocyanurate	8.800
2.	0.625 in plywood	0.780
3.	Carpet & pad	2.080
4.		
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

From EZFRAME = $\boxed{0.048}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.048} = \underset{\textbf{Total R-Value}}{20.950}$$

Reference Name: **FC.21.2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 8	
Framing Spacing:	16 "o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin ✓	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

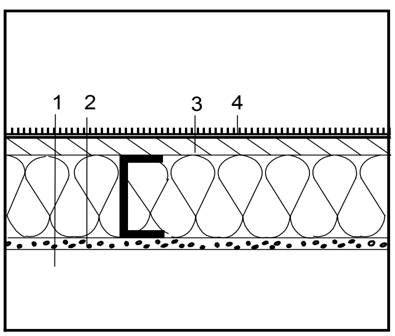
		R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Effective R-value of vented crawlspace	6.000	6.000
2.	R-21 fiberglass insulation	21.000	-----
3.	7.25 in fir framing	-----	7.178
4.	0.625 in plywood	0.780	0.780
5.	Carpet & pad	2.080	2.080
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	30.950	17.128
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\underset{1\div R_c}{1/30.950}\right) \times \left(\underset{1-(\text{Fr.\%}\div 100)}{1-10/100}\right)\right] + \left[\left(\underset{1\div R_f}{1/17.128}\right) \times \left(\underset{\text{Fr.\%}\div 100}{10/100}\right)\right] = \boxed{0.032}\ \textbf{Total U-factor}$$

$$\underset{1\div\text{Total U-factor}}{1/0.032} = 31.250\ \textbf{Total R-Value}$$

Reference Name: **FC.21.S2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 "o.c.	
Framing Size:	Actual Depth	8.000
	Actual Width	1.625
Cavity Insulation:	R-value	21.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

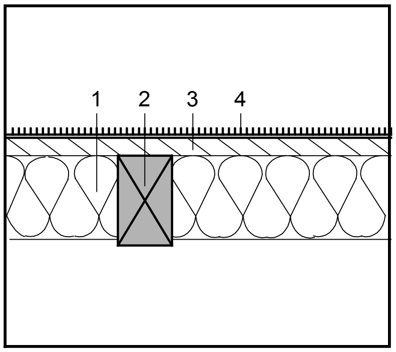
		R-Value
	Outside Surface Air Film	0.170
1.	Effective R-value of vented crawlspace	6.000
2.	1.50 in polyisocyanurate	10.560
3.	0.625 in plywood	0.780
4.	Carpet & pad	2.080
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

From EZFRAME = $\boxed{0.034}$ **Total U-factor**

$$\underset{1\div\text{Total U-factor}}{1/0.034} = 29.080\ \textbf{Total R-Value}$$

Reference Name: **FX.21.2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 8	
Framing Spacing:	16	"o.c.
Framing (check one)	Wall:	15%
		12%
		9% (48"o.c.)
	Floor/Ceilin ✓	10%
		7% (24"o.c.)
		4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA	

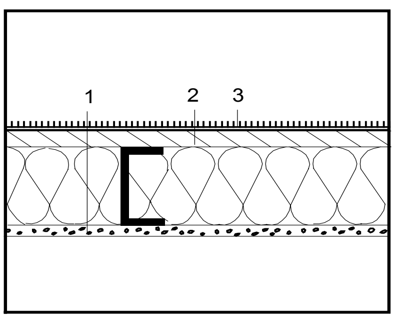
List of Construction Components	**R-Value** Cavity (R_c)	Frame (R_f)
Outside Surface Air Film	0.170	0.170
1. R-21 fiberglass insulation	21.000	-----
2. 7.25 in fir framing	-----	7.178
3. 0.625 in plywood	0.780	0.780
4. Carpet & pad	2.080	2.080
5.		
6.		
7.		
Inside Surface Air Film	0.920	0.920
Total Unadjusted R-Values:	24.950 R_c	11.128 R_f

Framing Adjustment Calculation:

$$\left[\left(\frac{1/24.950}{1\div R_c}\right) \times \left(\frac{1\text{-}10/100}{1\text{-}(\text{Fr.}\%\div 100)}\right)\right] + \left[\left(\frac{1/11.128}{1\div R_f}\right) \times \left(\frac{10/100}{\text{Fr.}\%\div 100}\right)\right] = \boxed{0.045}\ \textbf{Total U-factor}$$

$$\frac{1/0.045}{1\div\text{Total U-factor}} = 22.222\ \textbf{Total R-Value}$$

Reference Name: **FX.21.S2x8.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16	"o.c.
Framing Size:	Actual Depth	8.000
	Actual Width	1.625
Cavity Insulation:	R-value	21.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

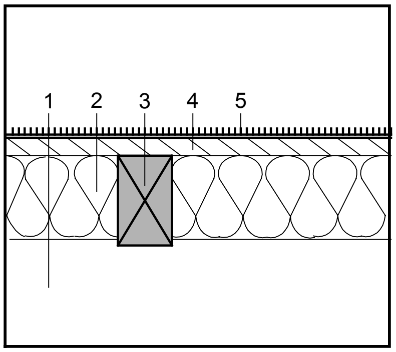
List of Construction Components	**R-Value**
Outside Surface Air Film	0.170
1. 1.50 in polyisocyanurate	10.560
2. 0.625 in plywood	0.780
3. Carpet & pad	2.080
4.	
5.	
6.	
7.	
Inside Surface Air Film	0.920

Calculation:

From EZFRAME = $\boxed{0.043}$ **Total U-factor**

$$\frac{1/0.043}{1\div\text{Total U-factor}} = 23.080\ \textbf{Total R-Value}$$

Reference Name: **FC.30.2x10.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor	
		Wall	
		Ceiling/Roof	
Framing Material:	Wood		
Framing Size:	2 × 8		
Framing Spacing:	16 "o.c.		
Framing (check one)	Wall:		15%
			12%
			9% (48"o.c.)
	Floor/Ceilin	✓	10%
			7% (24"o.c.)
			4% (48"o.c.)
Wall Weight / sf: (Packages only)	NA		

List of Construction Components | **R-Value**

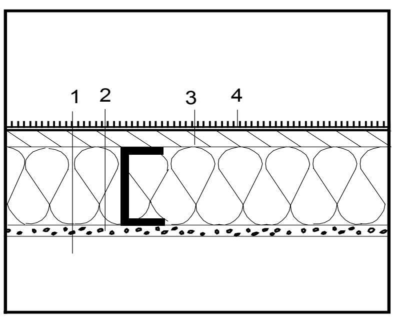
		Cavity (R_c)	Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	Effective R-value of vented crawlspace	6.000	6.000
2.	R-30 fiberglass insulation	30.000	-----
3.	9.25 in fir framing	-----	9.158
4.	0.625 in plywood	0.780	0.780
5.	Carpet & pad	2.080	2.080
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	39.950	19.028
		R_c	R_f

Framing Adjustment Calculation:

$$\left[\left(\frac{1/39.950}{1\div R_c}\right) \times \left(\frac{1-10/100}{1-(\text{Fr.\%}\div 100)}\right)\right] + \left[\left(\frac{1/19.028}{1\div R_f}\right) \times \left(\frac{10/100}{\text{Fr.\%}\div 100}\right)\right] = \boxed{0.028}\ \textbf{Total U-factor}$$

$$\frac{1/0.028}{1\div\text{Total U-factor}} = 35.714\ \textbf{Total R-Value}$$

Reference Name: **FC.30.S2x10.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor	
		Wall	
		Ceiling/Roof	
Framing Material:	Metal		
Framing Spacing:	16 "o.c.		
Framing Size:		Actual Depth	10.000
		Actual Width	1.625
Cavity Insulation:		R-value	30.000
		Knock-out (%)	15.000
		Web	0.060
Insulation Tape R-		Interior Flange	
		Exterior	

List of Construction Components | **R-Value**

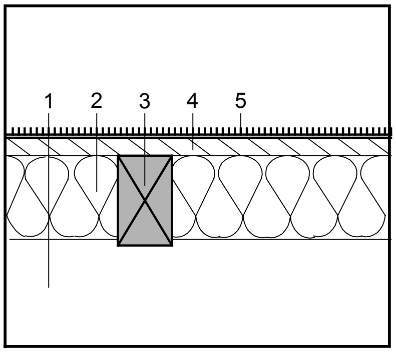
		R-Value
	Outside Surface Air Film	0.170
1.	Effective R-value of vented crawlspace	6.000
2.	2.50 in polyisocyanurate	17.600
3.	0.625 in plywood	0.780
4.	Carpet & pad	2.080
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

From EZFRAME = $\boxed{0.026}$ **Total U-factor**

$$\frac{1/0.026}{1\div\text{Total U-factor}} = 38.110\ \textbf{Total R-Value}$$

Reference Name: **FX.30.2x10.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Wood**	
Framing Size:	2 × 8	
Framing Spacing:	16 “o.c.	
Framing (check one)	Wall:	15%
		12%
		9% (48”o.c.)
	Floor/Ceilin ✓	10%
		7% (24”o.c.)
		4% (48”o.c.)
Wall Weight / sf: (Packages only)	NA	

List of Construction Components

	List of Construction Components	R-Value Cavity (R_c)	R-Value Frame (R_f)
	Outside Surface Air Film	0.170	0.170
1.	R-30 fiberglass insulation	30.000	-----
2.	9.25 in fir framing	-----	9.158
3.	0.625 in plywood	0.780	0.780
4.	Carpet & pad	2.080	2.080
5.			
6.			
7.			
	Inside Surface Air Film	0.920	0.920
	Total Unadjusted R-Values:	33.950 (R_c)	13.108 (R_f)

Framing Adjustment Calculation:

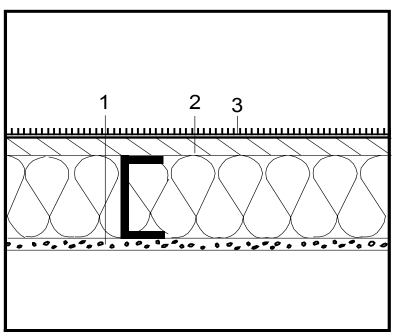
$$\left[\left(\frac{1/33.950}{1 \div R_c}\right) \times \left(\frac{1\text{-}10/100}{1\text{-}(\text{Fr.}\% \div 100)}\right)\right] + \left[\left(\frac{1/13.108}{1 \div R_f}\right) \times \left(\frac{10/100}{\text{Fr.}\% \div 100}\right)\right] = \boxed{0.034}$$

Total U-factor

$$\frac{1/0.034}{1 \div \text{Total U-factor}} = 29.412$$

Total R-Value

Reference Name: **FX.30.S2x10.16**



Sketch of Construction Assembly

Assembly Type: (check one)	✓	Floor
		Wall
		Ceiling/Roof
Framing Material:	**Metal**	
Framing Spacing:	16 “o.c.	
Framing Size:	Actual Depth	10.000
	Actual Width	1.625
Cavity Insulation:	R-value	38.000
	Knock-out (%)	15.000
	Web	0.060
Insulation Tape R-	Interior Flange	
	Exterior	

List of Construction Components

	List of Construction Components	R-Value
	Outside Surface Air Film	0.170
1.	2.50 in polyisocyanurate	17.600
2.	0.625 in plywood	0.780
3.	Carpet & pad	2.080
4.		
5.		
6.		
7.		
	Inside Surface Air Film	0.920

Calculation:

From EZFRAME = $\boxed{0.031}$ **Total U-factor**

$$\frac{1/0.031}{1 \div \text{Total U-factor}} = 32.110$$

Total R-Value

Computer Modeling of Framed Assemblies

EZFrame can be purchased by ordering the following:

Publication No.:	P400-94-002R
Cost:	$14.00
Address:	California Energy Commission Publications, MS-13 P.O. Box 944295 Sacramento, CA 94244-2950

For Questions call the Energy Hotline at 1-800-772-3300 (California Only) or 916-654-5106

Table B-8A–Fan Motor Efficiencies (< 1 HP)

Nameplate or Brake Horsepower	Standard Fan Motor Efficiency	NEMA* High Efficiency	Premium Efficiency
1/20	40%	...	...
1/12	49%	...	...
1/8	55%	...	...
1/6	60%	...	...
1/4	64%	...	...
1/3	66%	...	...
1/2	70%	76.0%	80.0%
3/4	72%	77.0%	84.0%

NOTE: For default drive efficiencies, See Section 4.2.2

*NEMA - Proposed standard using test procedures.
Minimum NEMA efficiency per test IEEE 112b Rating Method.

Table B-8B–Fan Motor Efficiencies (1 HP and over)

	Open Motors				Enclosed Motors			
Number of Poles Synchronous Speed	**2** **3600**	**4** **1800**	**6** **1200**	**8** **900**	**2** **3600**	**4** **1800**	**6** **1200**	**8** **900**
1	—	82.5	80.0	74.0	75.5	82.5	80.0	74.0
1.5	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
2	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
3	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0
5	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5
7.5	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15	89.5	91.0	92.0	89.5	90.2	91.0	90.2	88.5
20	90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5
25	91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5
30	91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0
40	91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0
50	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7
60	93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7
75	93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0
100	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0
125	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150	93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6
200	94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1
250	94.5	95.0	95.4	94.5	95.4	95.0	95.0	94.5
300	95.0	95.4	95.4	—	95.4	95.4	95.0	—
350	95.0	95.4	95.4	—	95.4	95.4	95.0	—
400	95.4	95.4	—	—	95.4	95.4	—	—
450	95.8	95.8	—	—	95.4	95.4	—	—
500	95.8	95.8	—	—	95.4	95.8	—	—

Table B-9A– ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS – MINIMUM EFFICIENCY REQUIREMENTS (TABLE 1-C1)

Equipment Type	Size Category	Sub-Category or Rating Condition	Efficiency prior to 10/29/2001[a]	Efficiency as of 10/29/2001 [a]	Test Procedure
Air Conditioners, Air Cooled	≥65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package	8.9 EER and 8.3 IPLV	10.3 EER[b]	ARI 210/240
	≥135,000 Btu/h and < 240,000 Btu/h	Split System and Single Package	8.5 EER and 7.5 IPLV	9.7 EER[b]	ARI 340/360
	≥ 240,000 Btu/h and <760,000 Btu/h	Split System and Single Package	8.5 EER and 7.5 IPLV	9.5 EER[b] and 9.7 IPLV[b]	
	≥760,000 Btu/h	Split System and Single Package	8.2 EER and 7.5 IPLV	9.2 EER[b] and 9.4 IPLV[b]	
Air Conditioners, Water and Evaporatively Cooled	> 65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package	10.5 EER and 9.7 IPLV	11.5 EER[b]	ARI 210/240
	≥135,000 Btu/h and ≤240,000 Btu/h	Split System and Single Package	9.6 EER 9.0 IPLV	11.0 EER[b]	ARI 340/360
	> 240,000 Btu/h	Split System and Single Package	9.6 EER 9.0 IPLV	11.0 EER[b] and 10.3 IPLV[b]	
Condensing Units, Air Cooled	≥135,000 Btu/h		9.9 EER 11.0 IPLV	10.1 EER and 11.2 IPLV	ARI 365
Condensing Units, Water or Evaporatively Cooled	≥135,000 Btu/h		12.9 EER 12.9 IPLV	13.1 EER and 13.1 IPLV	

[a] IPLVs are only applicable to equipment with capacity modulation.

[b] Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

Table B-9B– UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED – MINIMUM EFFICIENCY REQUIREMENTS (TABLE 1-C2)

Equipment Type	Size Category	Sub-Category or Rating Condition	Efficiency prior to 10/29/2001	Efficiency as of 10/29/2001[a]	Test Procedure
Air Cooled, (Cooling Mode)	≥65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package	8.9 EER 8.3 IPLV	10.1 EER[b]	ARI 210/240
	≥135,000 Btu/h and <240,000 Btu/h	Split System and Single Package	8.5 EER 7.5 IPLV	9.3 EER[b]	ARI 340/360
	≥240,000 Btu/h <760,000 Btu/h	Split System and Single Package	8.5 EER 7.5 IPLV	9.0 EER[b] 9.2 IPLV[b]	
	≥760,000 Btu/h □	Split System and Single Package	8.2 EER 7.5 IPLV	9.0 EER[b] 9.2 IPLV[b]	
Water-Source (Cooling Mode)	< 17,000 Btu/h	85°F Entering Water	10.0 EER		ARI 320
		86°F Entering Water		11.2 EER	ARI/ISO-13256-1
	≥ 17,000 Btu/h and <65,000 Btu/h	85°F Entering Water	10.0 EER		ARI 320
		86°F Entering Water		12.0 EER	ARI/ISO-13256-1
	≥65,000 Btu/h and < 135,000 Btu/h	85°F Entering Water	10.5 EER		ARI 320
		86°F Entering Water		12.0 EER	ARI/ISO-13256-1
Groundwater-Source (Cooling Mode)	< 135,000 Btu/h	70°F Entering Water	11.0 EER		ARI 325
		59°F Entering Water		16.2 EER	ARI/ISO-13256-1
Ground Source (Cooling Mode)	< 135,000 Btu/h	77°F Entering Water	N/A	13.4 EER	ARI/ISO-13256-1
Air Cooled (Heating Mode)	≥65,000 Btu/h and < 135,000 Btu/h (Cooling Capacity)	47°F db/43°F wb Outdoor Air	3.0 COP	3.2 COP	ARI 210/240
	≥135,000 Btu/h (Cooling Capacity)	47°F db/43°F wb Outdoor Air	2.9 COP	3.1 COP	ARI 340/360
Water-Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	70°F Entering Water	3.8 COP		ARI 320
		68°F Entering Water		4.2 COP	ARI/ISO-13256-1
Groundwater-Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	70°F Entering Water	3.5 COP		ARI 325
		50°F Entering Water		3.6 COP	ARI/ISO-13256-1
Ground Source (Heating Mode)	(Cooling Capacity)	32□F Entering Water	N/A	3.1 COP	ARI/ISO-13256-1

[a] IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.
[b] Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

Table B-9C– WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS (TABLE 1-C3)

Equipment Type	Size Category	Efficiency prior to 10/29/2001	Efficiency as of 10/29/2001	Test Procedure
Air Cooled, With Condenser, Electrically Operated	< 150 Tons	2.70 COP 2.80 IPLV	2.80 COP 2.80 IPLV	ARI 550 or ARI 590 as appropriate
	≥150 Tons	2.50 COP 2.50 IPLV		
Air Cooled, Without Condenser, Electrically Operated	All Capacities	3.10 COP 3.20 IPLV	3.10 COP 3.10 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities	3.80 COP 3.90 IPLV	4.20 COP 4.65 IPLV	ARI 590
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	< 150 Tons	3.80 COP 3.90 IPLV	4.45 COP 4.50 IPLV	ARI 550 or ARI 590 as appropriate
	≥150 Tons and < 300 Tons	4.20 COP 4.50 IPLV	4.90 COP 4.95 IPLV	
	≥300 Tons □	5.20 COP 5.30 IPLV	5.50 COP 5.60 IPLV	
Water Cooled, Electrically Operated, Centrifugal	< 150 Tons	3.80 COP 3.90 IPLV	5.00 COP 5.00 IPLV	ARI 550
	≥150 Tons and < 300 Tons	4.20 COP 4.50 IPLV	5.55 COP 5.55 IPLV	
	≥300 Tons □	5.20 COP 5.30 IPLV	6.10 COP 6.10 IPLV	
Air Cooled Absorption Single Effect	All Capacities	N/A	0.60 COP	ARI 560
Water Cooled Absorption Single Effect	All Capacities	N/A	0.70 COP	
Absorption Double Effect, Indirect-Fired	All Capacities	N/A N/A	1.00 COP 1.05 IPLV	
Absorption Double Effect, Direct-Fired	All Capacities	N/A N/A	1.00 COP 1.00 IPLV	

Table B-9D– PACKAGED TERMINAL AIR CONDITIONERS AND PACKAGED TERMINAL HEAT PUMPS – MINIMUM EFFICIENCY REQUIREMENTS (TABLE 1-C4)

Equipment Type	Size Category (Input)	Sub-Category or Rating Condition	Efficiency prior to 10/29/2001 [a]	Efficiency as of 10/29/2001[a]	Test Procedure
PTAC (Cooling Mode) New Construction	All Capacities	95°F db Outdoor Air	10.0 - (0.16 x Cap/1000)[a] EER	12.5 - (0.213 x Cap/1000)[a] EER	ARI 310/380
PTAC (Cooling Mode) Replacements[c]	All Capacities	95°F db Outdoor Air	10.0 - (0.16 x Cap/1000)[a] EER	10.9 - (0.213 x Cap/1000)[a] EER	
PTHP (Cooling Mode) New Construction	All Capacities	95°F db Outdoor Air	10.0 - (0.16 x Cap/1000)[a] EER	12.3 - (0.213 x Cap/1000)[a] EER	
PTHP (Cooling Mode) Replacements[c]	All Capacities	95°F db Outdoor Air	10.0 - (0.16 x Cap/1000)[a] EER	10.8 - (0.213 x Cap/1000)[a] EER	
PTHP (Heating Mode) New Construction	All Capacities		2.9 - (0.026 x Cap/1000)[a] COP	3.2 - (0.026 x Cap/1000)[a] COP	
PTHP (Heating Mode) Replacements[b]	All Capacities		2.9 - (0.026 x Cap/1000)[a] COP	2.9 - (0.026 x Cap/1000)[a] COP	

[a] Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
[B] Replacement units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16-in. high and less than 42-in. wide.

Table B-9E– WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS – MINIMUM EFFICIENCY REQUIREMENTS (TABLE 1-C5)

Equipment Type	Size Category (Input)	Sub-Category or Rating Condition	Efficiency prior to 10/29/2001[a]	Efficiency as of 10/29/2001	Test Procedure
Warm Air Furnace, Gas-Fired	≥225,000 Btu/h (66 kW)	Maximum Capacity	80% E_t	80% E_c[b]	ANSI Z21.47
		Minimum Capacity[c]	78% E_t		
Warm Air Furnace, Oil-Fired	≥225,000 Btu/h (66 kW)	Maximum Capacity	81% E_t	81% E_t[a]	UL 727
		Minimum Capacity[c]	81% E_t	——	
Warm Air Duct Furnaces, Gas-Fired	All Capacities	Maximum Capacity	80% E_t	80% E_c[b]	ANSI Z83.9
		Minimum Capacity[c]	75% E_t	——	
Warm Air Unit Heaters, Gas-Fired	All Capacities	Maximum Capacity	80% E_t	80% E_c[b]	ANSI Z83.8
		Minimum Capacity[c]	74% E_t	——	
Warm Air Unit Heaters, Oil-Fired	All Capacities	Maximum Capacity	81% E_t	80% E_c[b]	UL 731
		Minimum Capacity[c]	81% E_t	——	

[a] E_t = Thermal efficiency. See test procedure for detailed discussion.
[b] E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
[c] Minimum ratings as provided for and allowed by unit's controls.

Table B-9F– BOILERS, GAS- AND OIL-FIRED – MINIMUM EFFICIENCY REQUIREMENTS (TABLE 1-C6)

Equipment Type[f]	Size Category	Sub-Category or Rating Condition	Efficiency prior to 10/29/2001[d]	Efficiency as of 10/29/2001	Test Procedure
Boilers, Gas-Fired	≥300,000 Btu/h	Maximum Capacity[a]	80% E_c [b]	75% E_t [c]	H.I. Htg Boiler Standard
		Minimum Capacity[a]	80% E_c [b]		
	> 2,500,000 Btu/h[e]	Hot Water	80% E_c [b]	80% E_c [b]	
	> 2,500,000 Btu/h[e]	Steam	80% E_c [b]	80% E_c [b]	
Boilers, Oil-Fired	≥300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum Capacity[a]	83% E_c [b]	78% E_t [c]	H.I. Htg Boiler Standard
		Minimum Capacity[a]	83% E_c [b]	——	
	> 2,500,000 Btu/h[e]	Hot Water	83% E_c [b]	83% E_c [b]	
	> 2,500,000 Btu/h[e]	Steam	83% E_c [b]	83% E_c [b]	
Oil-Fired (Residual)	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity[a]	83% E_c [b]	78% E_t [c]	H.I. Htg Boiler Standard
		Minimum Capacity[a]	83% E_c [b]	——	
	> 2,500,000 Btu/h[e]	Hot Water	83% E_c [b]	83% E_c [b]	
	> 2,500,000 Btu/h[e]	Steam	83% E_c [b]	83% E_c [b]	

[a] Minimum and maximum ratings as provided for and allowed by the unit's controls.
[b] E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed information.
[c] E_t = Thermal efficiency. See test procedure for detailed information.
[d] Alternate test procedures used at the manufacturer's option are ASME PTC-4.1 for units over 5,000,000 Btu/h input, or ANSI Z21.13 for units greater than or equal to 300,000 Btu/h and less than or equal to 2,500,000 Btu/h input.
[e] These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers, and to all packaged boilers. minimum efficiency requirements for boilers cover all capacities of packaged boilers.

Table B-9G– PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT (TABLE 1-C7)

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Sub-Category or Rating Condition	Performance Required as of 10/29/2001[a,b]	Test Procedure
Propeller or Axial Fan Cooling Towers	All	95°F Entering Water 85°F Leaving Water 78°F wb Outdoor Air	≥38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal Fan Cooling Towers	All	95°F Entering Water 85°F Leaving Water 78°F wb Outdoor Air	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Air Cooled Condensers	All	125°F Condensing Temperature R22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering Drybulb	≥176,000 Btu/h·hp	ARI 460

[a] For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower divided by the fan nameplate rated motor power.
[b] For purposes of this table air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.

Table B-9H– COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS < 150 TONS (TABLE 1-C8)

Centrifugal Chillers < 150 Tons COP_{std} = 5.4								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP and IPLV (IPLV=COP)					
46	75	29	6.00	6.27	6.48	6.8	7.03	7.20
45	75	30	5.92	6.17	6.37	6.66	6.87	7.02
44	75	31	5.84	6.08	6.26	6.53	6.71	6.86
43	75	32	5.75	5.99	6.16	6.40	6.58	6.71
42	75	33	5.67	5.90	6.06	6.29	6.45	6.57
41	75	34	5.59	5.82	5.98	6.19	6.34	6.44
40	75	35	5.50	5.74	5.89	6.10	6.23	6.33
46	80	34	5.59	5.82	5.98	6.19	6.34	6.44
45	80	35	5.50	5.74	5.89	6.10	6.23	6.33
44	80	36	5.41	5.66	5.81	6.01	6.13	6.22
43	80	37	5.31	5.57	5.73	5.92	6.04	6.13
42	80	38	5.21	5.48	5.64	5.84	5.95	6.04
41	80	39	5.09	5.39	5.56	5.76	5.87	5.95
40	80	40	4.96	5.29	5.47	5.67	5.79	5.86
46	85	39	5.09	5.39	5.56	5.76	5.87	5.95
45	85	40	4.96	5.29	5.47	5.67	5.79	5.86
44	85	41	4.83	5.18	5.40	5.59	5.71	5.78
43	85	42	4.68	5.07	5.28	5.50	5.62	5.70
42	85	43	4.51	4.94	5.17	5.41	5.54	5.62
41	85	44	4.33	4.8	5.05	5.31	5.45	5.53
40	85	45	4.13	4.65	4.92	5.21	5.35	5.44
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature

[b] Condenser DT = Leaving Condenser Water Temperature (F) – Entering Condenser Water Temperature (F)

K_{adj} = 6.1507 - 0.30244(X) + 0.0062692$(X)^2$ - 0.000045595$(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

Table B-9I– COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS > 150 TONS, ≤ 300 TONS (TABLE 1-C9)

Centrifugal Chillers > 150 Tons, ≤ 300 Tons COP_{std} = 5.55								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP and IPLV (IPLV=COP)					
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22
44	75	31	6.00	6.24	6.43	6.71	6.9	7.05
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75
41	75	34	5.74	5.98	6.14	6.36	6.51	6.62
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51
46	80	34	5.74	5.98	6.14	6.36	6.51	6.62
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30
42	80	38	5.35	5.64	5.80	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11
45	85	40	5.10	5.44	5.62	5.83	5.95	6.03
44	85	41	4.96	5.33	**5.55**	5.74	5.86	5.94
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature

[b] Condenser DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

K_{adj} = 6.1507 - 0.30244(X) + 0.0062692$(X)^2$ - 0.000045595$(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

Table B-9J– COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS > 300 TONS (TABLE 1-C10)

Centrifugal Chillers > 300 Tons COP_{std} = 6.1								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP and IPLV (IPLV=COP)					
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16
45	75	30	6.71	6.99	7.21	7.55	7.78	7.96
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17
46	80	34	6.33	6.60	6.77	7.02	7.18	7.30
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65
44	85	41	5.47	5.87	**6.10**	6.33	6.47	6.55
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature

[b] Condenser DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

K_{adj} = 6.1507 - 0.30244(X) + 0.0062692$(X)^2$ - 0.000045595$(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

Table B-9K– MINIMUM EFFICIENCY REQUIREMENTS FOR WATER HEATING EQUIPMENT (TABLE 1-C11)

Equipment Type	Size Category	Sub-Category or Rating Condition	Performance Required prior to 10/29/2001[a, b]	Performance Required as of 10/29/2001[b]	Test Procedure
Gas Storage Water Heaters	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	78% E_t 7.47V + 655 SL, Btu/h	80% E_t (Q/800 + 110√V) SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	78% E_t 7.47V + 546 SL, Btu/h	80% E_t (Q/800 + 110√V)SL, Btu/h	
Gas Instantaneous Water Heaters	> 200,000 Btu/h[c]	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	80% E_t	ANSI Z21.10.3
	> 200,000 Btu/h[C]	≥ 4,000 Btu/h/gal and ≥ 10 gal	77% E_t 13.22V + 385 SL, Btu/h	80% E_t (Q/800 + 110√V) SL, Btu/h	
Oil Storage Water Heaters	> 105,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	78% E_t 7.47V + 655 SL, Btu/h	78% E_t (Q/800 + 110√V) SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	78% E_t 7.47V + 546 SL, Btu/h	78% E_t (Q/800 + 110√V) SL, Btu/h	
Oil Instantaneous Water Heaters	> 210,000 Btu/h[c]	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	80% E_t	ANSI Z21.10.3
	> 210,000 Btu/h[c]	≥ 4,000 Btu/h/gal and ≥ 10 gal	77% E_t 13.22V + 385 SL, Btu/h	78% E_t (Q/800 + 110√V) SL, Btu/h	

[a] Thermal efficiency (E_t) is a minimum requirements, while standby loss (SL) is a maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the EF equation, V is the rated volume in gallons. In the SL equation, V is the measured volume in gallons.

[b] Thermal efficiency (E_t) is a minimum requirements, while standby loss (SL) is a maximum Btu/h based on a 70° temperature difference between stored water and ambient requirements. In the EF equation, V is the rated volume in gallons. In the SL equation, V is the rated volume in gallons and Q is the nameplate input rate in Btu/h.

[c] Instantaneous water heaters with input rates below 200,000 Btu/hmust comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

Table B-10A–Illuminance Categories

NOTE: This table is taken from the *Office Lighting American National Standard Practice*, ANSI/IES RP-1, 1993. The table is produced in its entirely, including captions and footnotes. Permission to reprint is pending.

TABLE 3: Currently recommended illuminance categories for lighting design --target maintained values (See Table 4 for Illuminance Values). These recommendations provide a guide for efficient visual performance in office spaces rather than for safety alone. For a tabulation of minimum levels of illumination required for safety, see Table 7.

	Illuminance Category	Veiling Reflectance
Accounting		
(see individual tasks)		
Copied Tasks		
Ditto Copy (6)	E	!
Micro-fiche reader (1)	B	!!
Mimeograph	D	
Photographs, mod. detail	E	!!
Thermal copy, poor copy	F	!
Xerography, 3rd generation (6) and greater	E	
Xerograph	D	
Drafting Tasks		
Drafting: Mylar		
High contrast media; India ink, plastic leads, soft graphite leads	E	!
Low contrast media, hard graphite leads	F	!
Vellum: high contrast	E	!
low contrast	F	
Tracing paper: high contrast	E	!
low contrast	F	
Overlays (2)		
Light Table	C	
Prints: Blue Line	E	
Blueprints	E	
Sepia prints	F	
EDP Tasks		
CRT Screens (1)	B	!!
Impact printer: good ribbon	D	
poor ribbon (6)	E	
2nd carbon and greater (6)	E	
Ink jet printer	D	
Keyboard reading	D	
Machine rooms: active operations	D	
tape storage	D	
machine area	C	
equipement service (3)	E	
Thermal print	E	!
Filing		
(see individual tasks)		
General and Public Areas		
AV areas	D	
Conference rooms	D	
(critical seeing, refer to individual tasks)		
Display areas (4)	C	
Duplicating and off-set printing area	D	
Elevators	C	
Escalators	C	
First aid areas	E	
Food service (7)		
Hallways	B	
Janitorial spaces	C	
Libraries (7)		
Lobbies and lounges	C	
Model making	F	
Mail sorting	E	
Mechanical rooms: operation	B	
equipment service (3)	E	
Reception area	C	
Rest rooms	C	
Stairs	B	
Utility rooms	B	
Graphic Design and Material		
Color selection (5)	F	

Charting and mapping	F	
Graphs	E	
Keylining	F	
Layout and artwork	F	
Photographs, mod. detail	E	!!
Handwritten Tasks		
#2 pencil and softer leads	D	!
#3 pencil	E	!
#4 pencil and harder leads (6)	F	!
Ball-point pen	D	!
Felt-tip pen	D	
Handwritten carbon copies (6)	E	
Non photographically reproducible colors	F	
Printed Tasks		
6 pt (6) see 2.4	E	!
8 & 10 pt	D	!
Glossy magazines	D	!!
Maps	E	
Newsprint	D	
Typed Originals	D	
Typed 2nd carbon and later (6)	E	
Telephone books	E	

NOTES:

1. Veiling reflections may be produced on glass surfaces. It may be necessary to treat plus weighting factors as minus in order to obtain proper light balance.
2. Degradation factors: Overlays--add 1 weighing factor for each overlay
   Used material--estimate additional factors
   See Table 4
3. Only when actual equipment service is in progress. May be achieved by a general lighting system or by localized lighting or by portable equipment.
4. For details on the lighting of display refer to Recommended Practice for Lighting Merchandise Areas. (10)
5. For color matching, the quality of the color of the light source may be important.
6. Designing to higher levels to accommodate poor quality tasks should be undertaken only after it is determined that task quality cannot be improved. If a poor quality task cannot be eliminated, its "time-and-importance" factor should be carefully considered before allowing it to govern the illuminance level selection.
7. See Reference 9.

! Task subject to veiling reflections. Illuminance listed is not an ESI value. Currently, insufficient experience in the use of ESI target values precludes the direct use of Equivalent Sphere Illumination in the present consensus approach recommend illuminance values. Equivalent Sphere Illumination may be used as a tool in determining the effectiveness of controlling veiling reflections and as part of the evaluation of lighting systems.

!! Especially subject to veiling reflectances. It may be necessary to shield the task or to reorient it.

Definition of Merchandising and Associated Service Areas in Stores

NOTE: This table is taken from the *Recommended Practice for Lighting Merchandising Areas*, IES RP-2. The table is produced in its entirety, including captions and footnotes. Permission to reprint is pending.

Table B-10B–Currently Recommended Illuminance for Lighting Design in Merchandising and Associated Areas -- Target Maintained Levels

Areas or Tasks	Description	Type of Activity Area*	Lux	Foot-candles
Circulation	Area not used for display or appraisal of merchandise for sales transactions	High activity	300	30
		Medium activity	400	20
		Low activity	100	10
Merchandise*** (including showcases & wall displays)	That plane area, horizontal to vertical, where merchandise is displayed and readily accessible for customer examination	High activity	1000	100
		Medium activity	750	75
		Low activity	300	30
Show windows				
Daytime lighting				
General			2000	200
Feature			10000	1000
Nighttime lighting				
Main business districts-highly competitive				
General			2000	200
Feature			10000	1000
Secondary business districts or small towns				
General			1000	100
Feature			5000	500
Sales Transactions	Areas used for employee price verification and for recording transactions	Reading of copied, written, printed or EDP information	See Table 2	
Support Services	Store spaces where merchandising is a prime consideration	Alteration fitting stock, wrapping and packaging rooms	See Table 2	

NOTES:

* One store may encompass all three types within the building: High Activity area -- where merchandise displayed has recognizable usage. Evaluation and viewing time is rapid, and merchandise is sown to attract and stimulate the impulse buying decision; Medium Activity -- where merchandise is familiar in type or usage, but the customer may require time and/or help in evaluation of quality, usage, or for the decision to buy; and Low Activity -- where merchandise is displayed that is purchased less frequently by the customer, who may be unfamiliar with the inherent quality, design, value or usage. Where assistance and time is necessary to reach a buying decision.

** Maintained on the task or in the area at any time.

*** Lighting levels to be maintained in the plane of the merchandise.

Fig. 2-1–Currently Recommended Illuminance Categories and Illuminance Values for Lighting Design -Targeted Maintenance Levels

The tabulation that follows is a consolidated listing of the Society's current illuminance recommendations. This listing is intended to guide the lighting designer in selecting an appropriate illuminance for design and evaluation of lighting systems.

Guidance is provided in two forms: (1), in Parts I, II and III as an *Illuminance Category*, representing a range of illuminances (see page 2-3 for a method of selecting a value within each illuminance range); and (2), in parts IV, V and VI as an *Illuminance Value*. Illuminance Values are given in *lux* with an approximate equivalence in footcandles and as such are intended as *target* (nominal) values with deviations expected. These target values also represent maintained values (see page 2-23).

This table has been divided into the six parts for ease of use. Part I provides a listing of both Illuminance Categories and Illuminance Values for generic types of interior activities and normally is to be used when Illuminance Categories for a specific Area/Activity cannot be found in parts II and III. Parts IV, V and VI provide target maintained Illuminance Values for outdoor facilities sports and recreational areas, and transportation vehicles where special considerations apply as discussed on page 2-4.

In all cases the recommendations in this table are based on the assumption that the lighting will be properly designed to take into account the visual characteristics of the task. See the design information in the particular application sections in this Application Handbook for further recommendations.

Table B-10C–Illuminance Categories (Commercial, Institutional, Residential and Public Assembly Interiors)

NOTE: This table is taken from the Figure 2-2 of the IES Lighting Handbook 1982 Application Volume. Part II of the table is produced in its entirety, with captions and footnotes.

Area/Activity	Illuminance Category
Accounting (see **Reading**)	
Air terminals (see Transportation terminals)	
Armories	C[1]
Art galleries (see **Museums**)	
Auditoriums	
Assembly	C[1]
Social activity	B
Banks	
Lobby	
General	C
Writing area	D
Tellers' stations	E[3]
Barber shops and beauty parlors	E
Churches and synagogues	(see page 7-2)[4]
Club and lodge rooms	
Lounge and reading	D
Conference rooms	
Conferring	D
Critical seeing (refer to individual task)	
Court rooms	
Seating area	C
Court activity area	E[3]
Dance halls and discotheques	B
Study halls (see **Reading**)	
Typing (see **Reading**)	
Sports facilities (see Part V, Sports and	
Recreational Areas)	
Cafeterias (see **Food service facilities**)	
Dormitories (see **Residences**)	
Elevator, freight and passenger	C
Exhibition halls	C[1]
Filing (refer to individual task)	

Financial facilities (see **Banks**)	
Fire halls (see **Municipal buildings**)	
Food service facilities	
Dining areas	
Cashier	D
Cleaning	C
Dining	B[6]
Food displays (see **Merchandising spaces**)	
Kitchen	E
Garages -- parking	(see page 14-28)
Gasoline stations (see **Service stations**)	
Graphic design and material	
Color selection	F[11]
Charting and mapping	F
Graphs	E
Keylining	F
Layout and artwork	F
Photographs, moderate detail	E[13]
Health care facilities	
Ambulance (local)	E
Anesthetizing	E
Autopsy and morgue[17, 18]	
Autopsy, general	E
Autopsy table	G
Morgue, general	D
Museum	E
Cardiac function lab	E
Central sterile supply	
Inspection, general	E
Inspection	F
At sinks	E
Work areas, general	D
Processed storage	D
Corridors[17]	
Nursing areas -- day	C
Nursing areas -- night	B
Operating areas, delivery, recovery,	
and laboratory suites and service	E
Critical care areas[17]	
General	C
Examination	E
Surgical task lighting	H
Hand washing	F
Cystoscopy room [17,18]	
Dental suite [17]	
General	D
Instrument tray	E
Oral Cavity	H
Prosthetic laboratory, general	D
Prosthetic laboratory, work bench	E
Prosthetic, laboratory, local	F
Recovery room, general	C

Recovery room, emergency	
examination	E
Dialysis unit, medical[17]	F
Elevators	C
EKG and specimen room[17]	
General	B
On equipment	C
Emergency outpatient[17]	
General	E
Local	F
Endoscopy rooms [17, 18]	
General	E
Peritoneoscopy	D
Culdoscopy	D
Examination and treatment rooms [17]	
General	D
Local	E
Eye surgery[17, 18]	F
Fracture room[17]	
General	E
Local	F
Inhalation therapy	D
Laboratories[17]	
Specimen collecting	E
Tissue laboratories	F
Microscopic reading room	D
Gross specimen review	F
Chemistry rooms	E
Bacteriology rooms	
General	E
Reading culture plates	F
Hematology	E
Linens	
Sorting soiled linen	D
Central (clean) linen room	D
Sewing room, general	D
Sewing room, work area	E
Linen closet	B
Lobby	C
Locker rooms	C
Medical illustration studio[17, 18]	F
Medical records	E
Nurseries[17]	
General[18]	C
Observation and treatment	E
Nursing stations[17]	
General	D
Desk	E
Corridors, day	C
Corridors, night	A
Medication station	E
Obstetric delivery suite[17]	
Labor rooms	
General	C
Local	E
Birthing room	F
Delivery area	
Scrub, general	F
General	G
Delivery table	(see page 7-19)

Resuscitation	G
Post delivery recovery area	E
Substerilizing room	B
Occupational therapy[17]	
Work area, general	D
Work tables or benches	E
Patients' rooms[17]	
General[18]	B
Observation	A
Critical examination	E
Reading	D
Toilets	D
Pharmacy[17]	
General	E
Alcohol vault	D
Laminar flow bench	F
Night light	A
Parenteral solution room	D
Physical therapy departments	
Gymnasiums	D
Tank rooms	D
Treatment cubicles	D
Postanesthetic recovery room[17]	
General[18]	E
Local	H
Pulmonary function laboratories[17]	E
Radiological suite[17]	
Diagnostic section	
General[18]	A
Waiting area	A
Radiographic/fluoroscopic room	A
Film sorting	F
Barium kitchen	E
Radiation therapy section	
General[18]	B
Waiting area	B
Isotope kitchen, general	E
Isotope kitchen, benches	E
Computerized radiotomography section	
Scanning room	B
Equipment maintenance room	E
Solarium	
General	C
Local for reading	D
Stairways	C
Surgical suite[17]	
Operating room, general[18]	F
Operating table	(see page 7-15)
Scrub room	F
Instruments and sterile supply room	D
Clean up room, instruments	E
Anesthesia	C
Substerilizing room	C
Surgical induction room[17, 18]	E
Surgical holding area[17, 18]	E
Toilets	C
Utility room	D
Waiting areas[17]	
General	C
Local for reading	D
Homes (see **Residences**)	
Hospitality facilities	

(see **Hotels,** **food service facilities**)	
Hospitals (see **Health care facilities**)	
Hotels	
Bathrooms, for grooming	D
Bedrooms, for reading	D
Corridors, elevators and stairs	C
Front desk	E[3]
Linen room	
Sewing	F
General	C
Lobby	
General lighting	C
Reading and working areas	D
Canopy (see Part IV, Outdoor Facilities)	
Houses of worship	(see page 7-5)
Kitchens (see **Food service facilities** or **Residences**)	
Libraries	
Reading areas (see **Reading**)	
Libraries	
Book stacks [vertical 760 millimeters	
(30 inches) above floor]	
Active stacks	D
Inactive stacks	B
Book repair and binding	D
Cataloging	D[3]
Card files	E
Carrels, individual study areas	
(see **Reading**) Circulation desks	D
Map, picture and print rooms (see **Graphic design**	
and material)	
Audiovisual areas	D
Audio listening areas	D
Microform areas (see **Reading**)	
Locker rooms	C
Merchandising spaces	
Alteration room	F
Fitting room	
Dressing areas	D
Fitting areas	F
Locker rooms	C
Stock rooms, wrapping and packaging	D
Sales transaction area (see **Reading**)	
Circulating	(see page 8-7)[8]
Merchandise	(see page 8-7)[8]
Feature display	(see page 8-7)[8]
Show windows	(see page 8-7)[8]
Motels (see **Hotels**)	
Municipal buildings -- fire and police	
Police	
Identification records	F
Jail cells and interrogation rooms	D
Fire hall	D
Museums	
Displays of non-sensitive materials	D
Displays of sensitive materials	(see page 7-34)[2]
Lobbies, general gallery areas, corridors	C

Restoration or conservation shops	
and laboratories	E
Nursing homes (see **Health care facilities**)	
Offices	
Accounting (see **Reading**)	
Audio-visual areas	D
Conference areas (see **Conference rooms**)	
Drafting (see **Drafting**)	
General and private offices (see **Reading**)	
Libraries (see **Libraries**)	
Lobbies, lounges and reception areas	C
Mail sorting	E
Off-set printing and duplicating area	D
Spaces with VDTs	(see page 5-13)
Parking facilities	(see page 14-28)
Post offices (see **Offices**)	
Reading	
Copied tasks	
Ditto copy	E[3]
Micro-fiche reader	B[12, 13]
Mimeograph	D
Photograph, moderate detail	E[13]
Thermal copy, poor copy	F[3]
Xerography	D
Xerography, 3rd generation and	
greater	E
Electronic data processing tasks	
CRT screens	B[12, 13]
Impact printer	
good ribbon	D
poor ribbon	E
2nd carbon and greater	E
Ink jet printer	D
Keyboard reading	D
Machine rooms	
Active operations	D
Tape storage	D
Machine area	C
Equipment service	E[10]
Thermal print	E
Handwritten tasks	
#2 pencil and softer leads	D[3]
#3 pencil	E[3]
#4 pencil and harder leads	F[3]
Ball-point pen	D[3]
Felt-tip pen	D
Handwritten carbon copies	E
Non photographically reproducible colors	F
Chalkboards	E[3]
Printed tasks	
6 point type	E[3]
8 and 10 point type	D[3]
Glossy magazines	D[13]
Maps	E
Newsprint	D
Typed originals	D
Typed 2nd carbon and later	E
Telephone books	E

Residences	
General lighting	
Conversation, relaxation and entertainment	B
Passage areas	B
Specific visual tasks[20]	
Dining	C
Grooming	
Makeup and shaving	D
Full-length mirror	D
Handcrafts and hobbies	
Workbench hobbies	
Ordinary tasks	D
Difficult tasks	E
Critical tasks	F
Easel hobbies	E
Ironing	D
Kitchen duties	
Kitchen counter	
Critical seeing	E
Noncritical	D
Kitchen range	
Difficult seeing	E
Noncritical	D
Kitchen sink	
Difficult seeing	E
Noncritical	D
Laundry	
Preparation and tubs	D
Washer and dryer	D
Music study (piano or organ)	
Simple scores	D
Advanced scores	E
Substandard size scores	F
Reading	
In a chair	
Books, magazines and newspapers	D
Handwriting, reproductions and	
poor copies	E
In bed	
Normal	D
Prolonged serious or critical	E
Desk	
Primary task plane, casual	D
Primary task plane, study	E
Sewing	
Hand sewing	
Dark fabrics, low contrast	F
Light to medium fabrics	E
Occasional, high contrast	D
Machine sewing	
Dark fabrics, low contrast	F
Light to medium fabrics	E
Occasional, high contrast	D
Table games	D
Restaurants (see **Food service facilities**)	
Safety	(see page 2-45)
Schools (see **Educational facilities**)	
Service spaces (see also **Storage rooms**)	
Stairways, corridors	C
Elevators, freight and passenger	C
Toilet and washroom	C

Service stations	
Service bays (see Part III, Industrial Group)	
Sales room (see **Merchandising spaces**)	
Show windows	(see page 8-7)
Stairways (see **Service spaces**)	
Storage rooms (see Part III, Industrial Group)	
Stores (see **Merchandising spaces** and **Show windows**)	
Television	(see Section 11)
Theater and motion picture houses	(see Section 11)
Toilets and washrooms	C
Transportation terminals	
Waiting room and lounge	C
Ticket counters	E
Baggage checking	D
Rest rooms	C
Concourse	B
Boarding area	C

Notes:
[1]Include provisions for higher levels for exhibitions.
[2]Specific limits are provided to minimize deterioration effects.
[3]Task subject to veiling reflections. Illuminance listed is not an Equivalent Sphere Illumination (ESI) value. Currently, insufficient experience in the use of ESI target values precludes the direct use of ESI in the present consensus approach to recommend illuminance values. ESI may be used as a tool in determining the effectiveness of controlling veiling reflections and as a part of the evaluation of lighting systems.
[4]Illuminance values are listed based on experience and consensus. Values relate to needs during various religious ceremonies.
[5]Degradation factors: Overlays -- add 2 weighting factor for each overlay; Used material -- estimate additional factors.
[6]Provide higher level over food service or selection areas.
[7]Supplementary illumination as in delivery room must be available.
8Illuminance values developed for various degrees of store area activity.
[9]Or not less than 1/5 the level in the adjacent areas.
[10]Only when actual equipment service is in process. May be achieved by a general lighting system or by localized or portable equipment.
[11]For color matching, the spectral quality of the color of the light source is important.
[12]Veiling reflections may be produced on glass surfaces. It may be necessary to treat plus weighting factors as minus in order to obtain proper illuminance.
[13]Especially subject to veiling reflections. It may be necessary to shield the task or to reorient it.
[14]Vertical
[15]Illuminance values may vary widely, depending upon the effect desired, the decorative scheme, and the use made of the room.
[16]Supplementary lighting should be provided in this space to produce the higher levels required for specific seeing tasks involved.
[17]Good to high color rendering capability should be considered in these areas. As lamps of higher luminous efficacy and higher color rendering capability become available and economically feasible, they should be applied in all areas of health care facilities.
[18]Variable (dimming or switching).
[19]Values based on a 25 percent reflectance, which is average for vegetation and typical outdoor surfaces. These figures must be adjusted to specific reflectances of materials lighted for equivalent brightness. Levels give satisfactory brightness patterns when viewed from dimly lighted terraces or interiors. When viewed from dark areas they may be reduced by at least 1/2; or they may be doubled when a high key is desired.
[20]General lighting should not be less than 1/3 of visual task illuminance nor less than 200 lux [20 footcandles].
[21]Industry representatives have established a table of single illuminance values which, in their opinion, can be used in preference to employing reference 6. Illuminance values for specific operations can also be determined using illuminance categories of similar tasks and activities found in this table and the application of the appropriate weighting factors in Fig. 2-3.
[22]Special lighting such that (1) the luminous area is large enough to cover the surface, which is being inspected and (2) the luminance is within the limits necessary to obtain comfortable contrast conditions. This involves the use of sources of large area and relatively low luminance in which the source luminance is the principal factor rather than the illuminance produced at a given point.
[23]Maximum levels -- controlled system.
[24]Additional lighting needs to be provided for maintenance only.
[25]Color temperature of the light source is important for color matching.
[26] Select upper level for high speed conveyor systems. For grading redwood lumber 3000 lux [300 footcandles] is required.
[27]Higher levels from local lighting may be required for manually operated cutting machines.
[28]If color matching is critical, use illuminance category G.

Table B-11–Luminaire Power

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
Fluorescent Circline						
Fluorescent Circline, Rapid Start (22 W)						
1	FC8T9	1	MAG STD	Magnetic Standard	27	8" OD
Fluorescent Circline, Rapid Start (32 W)						
1	FC12T9	1	MAG STD	Magnetic Standard	45	12" OD
Fluorescent Circline, Rapid Start (40 W)						
1	FC16T9	1	MAG STD	Magnetic Standard	57	16" OD
Fluorescent 2D						
Compact Fluorescent 2D (10W, GR10q-4 Four Pin Base)						
1	CFS10W/GR10q	1	MAG STD	Magnetic Standard	16	3.6" across
1	CFS10W/GR10q	1	ELECT	Electronic	13	
2	CFS10W/GR10q	1	ELECT	Electronic	26	
Compact Fluorescent 2D (16W, GR10q-4 Four Pin Base)						
1	CFS16W/GR10q	1	MAG STD	Magnetic Standard	23	5.5" across
1	CFS16W/GR10q	1	ELECT	Electronic	15	
2	CFS16W/GR10q	1	ELECT	Electronic	30	
Compact Fluorescent 2D (21W, GR10q-4 Four Pin Base)						
1	CFS21W/GR10q	1	MAG STD	Magnetic Standard	31	5.5" across
1	CFS21W/GR10q	1	ELECT	Electronic	21	
2	CFS21W/GR10q	1	ELECT	Electronic	42	
Compact Fluorescent 2D (28W, GR10q-4 Four Pin Base)						
1	CFS28W/GR10q	1	MAG STD	Magnetic Standard	38	8.1" across
1	CFS28W/GR10q	1	ELECT	Electronic	28	
2	CFS28W/GR10q	1	ELECT	Electronic	56	
Compact Fluorescent 2D (38W, GR10q-4 Four Pin Base)						
1	CFS38W/GR10q	1	ELECT	Electronic	37	8.1" across
2	CFS38W/GR10q	1	ELECT	Electronic	74	
Compact Fluorescent Twin (5 W, G23 Two Pin Base - F5TT Lamp)						
1	CFT5W/G23	1	MAG STD	Magnetic Standard	9	4.1" MOL
2	CFT5W/G23	2	MAG STD	Magnetic Standard	18	
Compact Fluorescent Twin (7 W, G23 Two Pin Base - F7TT Lamp)						
1	CFT7W/G23	1	MAG STD	Magnetic Standard	11	5.3" MOL
2	CFT7W/G23	2	MAG STD	Magnetic Standard	22	

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
Compact Fluorescent Twin (9 W, G23 Two Pin Base - F9TT Lamp)						
1	CFT9W/G23	1	MAG STD	Magnetic Standard	13	6.5" MOL
2	CFT9W/G23	2	MAG STD	Magnetic Standard	26	
Compact Fluorescent Twin (13 W, GX23 Two Pin Base - F13TT)						
1	CFT13W/GX23	1	MAG STD	Magnetic Standard	17	7.5" MOL
2	CFT13W/GX23	2	MAG STD	Magnetic Standard	34	
Compact Fluorescent Quad (9 W, G23-2 Two Pin Base - F9DTT Lamp)						
1	CFQ9W/G23-2	1	MAG STD 120	120 V Magnetic Standard	13	4.4" MOL
2	CFQ9W/G23-2	2	MAG STD 120	120 V Magnetic Standard	26	
Compact Fluorescent Quad (13 W, G24d-1 Two Pin Base - F13DTT Lamp)						
1	CFQ13W/G24d-1	1	MAG STD 120	120 V Magnetic Standard	18	6.0" MOL
2	CFQ13W/G24d-1	2	MAG STD 120	120 V Magnetic Standard	36	
1	CFQ13W/G24d-1	1	MAG STD 277	227 V Magnetic Standard	16	
2	CFQ13W/G24d-1	2	MAG STD 277	227 V Magnetic Standard	32	
Compact Fluorescent Quad (13 W, GX23-2 Two Pin Base)						
1	CFQ13W/GX23-2	1	MAG STD	Magnetic Standard	17	4.8" MOL
2	CFQ13W/GX23-2	2	MAG STD	Magnetic Standard	34	
Compact Fluorescent Quad (16W GX32d-1 Two Pin Base)						
1	CFQ16W/GX32d-1	1	MAG STD	Magnetic Standard	20	5.5" MOL
2	CFQ16W/GX32d-1	2	MAG STD	Magnetic Standard	40	
Compact Fluorescent Quad (18 W, G24d-2 Two Pin Base - F18DTT Lamp)						
1	CFQ18W/G24d-2	1	MAG STD 120	120 V Magnetic Standard	25	6.8" MOL
2	CFQ18W/G24d-2	2	MAG STD 120	120 V Magnetic Standard	50	
1	CFQ18W/G24d-2	1	MAG STD 277	227 V Magnetic Standard	22	
2	CFQ18W/G24d-2	2	MAG STD 277	227 V Magnetic Standard	44	
Compact Fluorescent Quad (22W, GX32d Two Pin Base)						
1	CFQ22W/GX32d-2	1	MAG STD	Magnetic Standard	27	6.0" MOL
2	CFQ22W/GX32d-2	2	MAG STD	Magnetic Standard	54	
Compact Fluorescent Quad (26 W, G24d-3 Two Pin Base - F26DTT Lamp)						
1	CFQ26W/G24d-3	1	MAG STD 120	120 V Magnetic Standard	37	7.6" MOL
2	CFQ26W/G24d-3	2	MAG STD 120	120 V Magnetic Standard	74	
1	CFQ26W/G24d-3	1	MAG STD 277	227 V Magnetic Standard	33	
2	CFQ26W/G24d-3	2	MAG STD 277	227 V Magnetic Standard	66	
1	CFQ26W/G24d-3	1	ELECT 277V	277 V Electronic	27	
2	CFQ26W/G24d-3	2	ELECT 277V	277 V Electronic	54	

Table B-11–Luminaire Power (continued)

LUMINAIRE POWER

Lamp		Ballast			Watts/	
No.	Designation	No.	Abbreviation	Description	Luminaire	Comments
Compact Fluorescent Quad (28W GX32d Two Pin Base)						
1	CFQ28W/GX32d-3	1	MAG STD	Magnetic Standard	34	6.8" MOL
2	CFQ28W/GX32d-3	2	MAG STD	Magnetic Standard	68	
Compact Fluorescent Quad (10 W, G24q-1 Four Pin Base)						
1	CFQ10W/G24q-1	1	MAG STD 120	120 V Magnetic Standard	16	4.6" MOL
2	CFQ10W/G24q-1	2	MAG STD 120	120 V Magnetic Standard	32	
1	CFQ10W/G24q-1	1	MAG STD 277	227 V Magnetic Standard	13	
2	CFQ10W/G24q-1	2	MAG STD 277	227 V Magnetic Standard	26	
Compact Fluorescent Quad (13 W, G24q-1 Four Pin Base)						
1	CFQ13W/G24q-1	1	MAG STD 120	120 V Magnetic Standard	18	6.0" MOL
2	CFQ13W/G24q-1	2	MAG STD 120	120 V Magnetic Standard	36	
1	CFQ13W/G24q-1	1	MAG STD 277	227 V Magnetic Standard	16	
2	CFQ13W/G24q-1	2	MAG STD 277	227 V Magnetic Standard	32	
Compact Fluorescent Quad (13 W, GX7 Four Pin Base)						
1	CFQ13W/GX7	1	MAG STD	Magnetic Standard	17	4.8" MOL
2	CFQ13W/GX7	2	MAG STD	Magnetic Standard	34	
Compact Fluorescent Quad (18 W, G24q-2 Four Pin Base)						
1	CFQ18W/G24q-2	1	MAG STD 120	120 V Magnetic Standard	25	6.8" MOL
2	CFQ18W/G24q-2	2	MAG STD 120	120 V Magnetic Standard	50	
1	CFQ18W/G24q-2	1	MAG STD 277	227 V Magnetic Standard	22	
2	CFQ18W/G24q-2	2	MAG STD 277	227 V Magnetic Standard	44	
Compact Fluorescent Triple (13 W, GX24q-1 Four Pin Base)						
1	CFM 13W/GX24q-1	1	MAG STD	Magnetic Standard	18	4.2" MOL
2	CFM 13W/GX24q-1	2	MAG STD	Magnetic Standard	36	
Compact Fluorescent Triple (18W, GX24q-2 Four Pin Base)						
1	CFM 18W/GX24q-2	1	MAG STD	Magnetic Standard	25	5.0" MOL
2	CFM 18W/GX24q-2	2	MAG STD	Magnetic Standard	50	
Compact Fluorescent Triple (26W, GX24q-3 Four Pin Base)						
1	CFM 26W/GX24q-3	1	MAG STD	Magnetic Standard	37	4.9 to 5.4" MOL
2	CFM 26W/GX24q-3	2	MAG STD	Magnetic Standard	74	

Table B-11–Luminaire Power (continued)

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
Fluorescent Twin (18W - F18TT Lamp)						
1	FT18W/2G11	1	MAG EE	Magnetic Energy Efficient	23	
2	FT18W/2G11	1	MAG EE	Magnetic Energy Efficient	46	
3	FT18W/2G11	1.5	MAG EE	Magnetic Energy Efficient	69	Tandem wired
3	FT18W/2G11	2	MAG EE	Magnetic Energy Efficient	69	
4	FT18W/2G11	2	MAG EE	Magnetic Energy Efficient	92	(2) Two-lamp ballasts
1	FT18W/2G11	1	ELECT	Electronic	17	
2	FT18W/2G11	1	ELECT	Electronic	35	
3	FT18W/2G11	1.5	ELECT	Electronic	52	Tandem wired
3	FT18W/2G11	2	ELECT	Electronic	52	
4	FT18W/2G11	2	ELECT	Electronic	70	(2) Two-lamp ballasts
Fluorescent Twin (24-27W- F24TT or F27TT Lamp)						
1	FT24W/2G11	1	MAG EE	Magnetic Energy Efficient	32	
2	FT24W/2G11	1	MAG EE	Magnetic Energy Efficient	66	
3	FT24W/2G11	1.5	MAG EE	Magnetic Energy Efficient	99	Tandem wired
3	FT24W/2G11	2	MAG EE	Magnetic Energy Efficient	98	
4	FT24W/2G11	2	MAG EE	Magnetic Energy Efficient	132	(2) Two-lamp ballasts
1	FT24W/2G11	1	ELECT	Electronic	21	
2	FT24W/2G11	1	ELECT	Electronic	43	
3	FT24W/2G11	1.5	ELECT	Electronic	64	Tandem wired
3	FT24W/2G11	2	ELECT	Electronic	64	
4	FT24W/2G11	2	ELECT	Electronic	86	(2) Two-lamp ballasts
Fluorescent Twin (36-39W - F36TT or F39TT Lamp)						
1	FT36W/2G11	1	MAG EE	Magnetic Energy Efficient	51	
2	FT36W/2G11	1	MAG EE	Magnetic Energy Efficient	66	
3	FT36W/2G11	1.5	MAG EE	Magnetic Energy Efficient	99	Tandem wired
3	FT36W/2G11	2	MAG EE	Magnetic Energy Efficient	117	
4	FT36W/2G11	2	MAG EE	Magnetic Energy Efficient	132	(2) Two-lamp ballasts
1	FT36W/2G11	1	ELECT	Electronic	37	
2	FT36W/2G11	1	ELECT	Electronic	70	
3	FT36W/2G11	1.5	ELECT	Electronic	105	Tandem wired
3	FT36W/2G11	2	ELECT	Electronic	107	
4	FT36W/2G11	2	ELECT	Electronic	140	(2) Two-lamp ballasts

LUMINAIRE LUMIN.

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
Fluorescent Twin (40 W - F40TT Lamp)						
1	FT40W/2G11	1	MAG EE	Magnetic Energy Efficient	43	
2	FT40W/2G11	1	MAG EE	Magnetic Energy Efficient	86	
3	FT40W/2G11	1.5	MAG EE	Magnetic Energy Efficient	129	Tandem wired
3	FT40W/2G11	2	MAG EE	Magnetic Energy Efficient	130	
4	FT40W/2G11	2	MAG EE	Magnetic Energy Efficient	172	(2) Two-lamp ballasts
1	FT40W/2G11	1	ELECT	Electronic	36	
2	FT40W/2G11	1	ELECT	Electronic	71	
2	FT40W/2G11	1	ELECT	Electronic	70	
3	FT40W/2G11	1	ELECT	Electronic	98	
3	FT40W/2G11	1.5	ELECT	Electronic	106	Tandem wired
3	FT40W/2G11	2	ELECT	Electronic	107	
4	FT40W/2G11	2	ELECT	Electronic	142	(2) Two-lamp ballasts
2	FT40W/2G11	1	ELECT RO	Elec. Reduce Output (75%)	59	
3	FT40W/2G11	1.5	ELECT DIM	Electronic Dimming (to 1%)	105	Tandem wired
4	FT40W/2G11	2	ELECT DIM	Electronic Dimming (to 1%)	140	(2) two-lamp ballasts
Fluorescent Twin (50 W - F50TT Lamp)						
1	FT50W/2G11	1	ELECT	Electronic	54	
2	FT50W/2G11	1	ELECT	Electronic	106	
3	FT50W/2G11	1	ELECT	Electronic	98	
3	FT50W/2G11	1.5	ELECT	Electronic	159	Tandem wired
3	FT50W/2G11	2	ELECT	Electronic	160	
4	FT50W/2G11	2	ELECT	Electronic	212	(2) Two-lamp ballasts
Fluorescent Twin (55 W - F55TT Lamp)						
1	FT55W/2G11	1	ELECT	Electronic	62	
2 ft. Fluorescent U-Tube Octic (32W - FBO31T8 Lamp)						
1	FB31T8	0.5	MAG EE	Magnetic Energy Efficient	35	Tandem wired
1	FB31T8	1	MAG EE	Magnetic Energy Efficient	36	
2	FB31T8	1	MAG EE	Magnetic Energy Efficient	69	
3	FB31T8	1.5	MAG EE	Magnetic Energy Efficient	104	Tandem wired
3	FB31T8	2	MAG EE	Magnetic Energy Efficient	105	

Table B-11–Luminaire Power (continued)

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
1	FB31T8	0.5	ELECT	Electronic	31	Tandem wired
1	FB31T8	1	ELECT	Electronic	39	
2	FB31T8	1	ELECT	Electronic	62	
3	FB31T8	1	ELECT	Electronic	92	
3	FB31T8	1.5	ELECT	Electronic	93	Tandem wired
3	FB31T8	2	ELECT	Electronic	101	
2	FB31T8	1	ELECT IS	Electronic Instant Start	61	
3	FB31T8	1	ELECT IS	Electronic Instant Start	88	
2 ft. Fluorescent U-Tube Energy-Saving (34W)						
1	FB40T12/ES	0.5	MAG EE	Magnetic Energy Efficient	36	Tandem wired
1	FB40T12/ES	1	MAG EE	Magnetic Energy Efficient	43	
2	FB40T12/ES	1	MAG EE	Magnetic Energy Efficient	72	
3	FB40T12/ES	1	MAG EE	Magnetic Energy Efficient	105	
3	FB40T12/ES	1.5	MAG EE	Magnetic Energy Efficient	108	Tandem wired
3	FB40T12/ES	2	MAG EE	Magnetic Energy Efficient	115	
1	FB40T12/ES	0.5	ELECT	Electronic	30	Tandem wired
1	FB40T12/ES	1	ELECT	Electronic	31	
2	FB40T12/ES	1	ELECT	Electronic	59	
3	FB40T12/ES	1	ELECT	Electronic	90	
3	FB40T12/ES	1.5	ELECT	Electronic	88	Tandem wired
3	FB40T12/ES	2	ELECT	Electronic	90	
2 ft. Fluorescent U-Tube Standard (40W - FB40T12 Lamp)						
1	FB40T12	0.5	MAG EE	Magnetic Energy Efficient	43	Tandem wired
1	FB40T12	1	MAG EE	Magnetic Energy Efficient	48	
2	FB40T12	1	MAG EE	Magnetic Energy Efficient	86	
3	FB40T12	1	MAG EE	Magnetic Energy Efficient	127	
3	FB40T12	1.5	MAG EE	Magnetic Energy Efficient	129	Tandem wired
3	FB40T12	2	MAG EE	Magnetic Energy Efficient	134	
1	FB40T12	0.5	ELECT	Electronic	35	Tandem wired
1	FB40T12	1	ELECT	Electronic	36	
2	FB40T12	1	ELECT	Electronic	67	
3	FB40T12	1	ELECT	Electronic	100	
3	FB40T12	1.5	ELECT	Electronic	101	Tandem wired
3	FB40T12	2	ELECT	Electronic	103	

Table B-11–Luminaire Power (continued)

LUMINAIRE POWER

Lamp		Ballast			Watts/ Luminaire	Comments
No.	Designation	No.	Abbreviation	Description		
Fluorescent Preheat T5 (4W)						
1	F4T5	1	MAG STD	Magnetic Standard	8	6" MOL
Fluorescent Preheat T5 (6W)						
1	F6T5	1	MAG STD	Magnetic Standard	10	9" MOL
Fluorescent Preheat T5 (8W)						
1	F8T5	1	MAG STD	Magnetic Standard	12	12" MOL
Fluorescent Preheat T8 (15W)						
1	F15T8	1	MAG STD	Magnetic Standard	19	18" MOL
Fluorescent Preheat T12 (15W)						
1	F15T12	1	MAG STD	Magnetic Standard	19	18" MOL
Fluorescent Preheat T12 (20W)						
1	F20T12	1	MAG STD	Magnetic Standard	25	24" MOL
2	F20T12	1	MAG STD	Magnetic Standard	50	24" MOL
Fluorescent Preheat T8 (30W)						
1	F30T8	1	MAG STD	Magnetic Standard	46	30" MOL
2	F30T8	1	MAG STD	Magnetic Standard	79	30" MOL
Fluorescent Preheat T12 (30W)						
1	F30T12	1	MAG STD	Magnetic Standard	46	30" MOL
2	F30T12	1	MAG STD	Magnetic Standard	79	30" MOL
2	F30T12	1	MAG EE	Magnetic Energy Efficient	74	30" MOL
1	F30T12	1	ELECT	Electronic	31	30" MOL
2	F30T12	2	ELECT	Electronic	63	30" MOL
2 foot Fluorescent Rapid Start T8 (17W)						
1	F17T8	1	MAG EE	Magnetic Energy Efficient	24	
2	F17T8	1	MAG EE	Magnetic Energy Efficient	45	
1	F17T8	1	ELECT	Electronic	22	
2	F17T8	1	ELECT	Electronic	33	
3	F17T8	1	ELECT	Electronic	53	
3	F17T8	2	ELECT	Electronic	55	
4	F17T8	1	ELECT	Electronic	63	
4	F17T8	2	ELECT	Electronic	66	(2) two-lamp ballasts

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
3 foot Fluorescent Rapid Start T8 (25W)						
1	F25T8	1	MAG EE	Magnetic Energy Efficient	33	
2	F25T8	1	MAG EE	Magnetic Energy Efficient	65	
1	F25T8	1	ELECT	Electronic	27	
2	F25T8	1	ELECT	Electronic	48	
3	F25T8	1	ELECT	Electronic	68	
3	F25T8	2	ELECT	Electronic	75	
4	F25T8	1	ELECT	Electronic	89	
4	F25T8	2	ELECT	Electronic	96	(2) two-lamp ballasts
4 foot Fluorescent Rapid Start Octic (32W)						
1	F32T8	0.5	MAG EE	Magnetic Energy Efficient	35	Tandem wired
1	F32T8	1	MAG EE	Magnetic Energy Efficient	39	
2	F32T8	1	MAG EE	Magnetic Energy Efficient	70	
3	F32T8	1.5	MAG EE	Magnetic Energy Efficient	105	Tandem wired
3	F32T8	2	MAG EE	Magnetic Energy Efficient	109	
4	F32T8	2	MAG EE	Magnetic Energy Efficient	140	(2) two-lamp ballasts
1	F32T8	0.5	ELECT	Electronic	31	Tandem wired
1	F32T8	1	ELECT	Electronic	32	
2	F32T8	1	ELECT	Electronic	62	
3	F32T8	1	ELECT	Electronic	93	
3	F32T8	1.5	ELECT	Electronic	93	Tandem wired
3	F32T8	2	ELECT	Electronic	94	
4	F32T8	1	ELECT	Electronic	114	
4	F32T8	2	ELECT	Electronic	124	(2) two-lamp ballasts
2	F32T8	1	ELECT IS	Electronic Instant Start	63	
3	F32T8	1	ELECT IS	Electronic Instant Start	96	
3	F32T8	1.5	ELECT IS	Electronic Instant Start	95	Tandem wired
4	F32T8	1	ELECT IS	Electronic Instant Start	124	
4	F32T8	2	ELECT IS	Electronic Instant Start	126	(2) two-lamp ballasts

Table B-11–Luminaire Power (continued)

LUMINAIRE POWER

Lamp		Ballast			Watts/	
No.	Designation	No.	Abbreviation	Description	Luminaire	Comments
4 foot Fluorescent Rapid Start Octic (32W) (cont.)						
2	F32T8	1	ELECT RO	Electronic Reduce Output (75%)	51	
3	F32T8	1	ELECT RO	Electronic Reduce Output (75%)	76	
3	F32T8	1.5	ELECT RO	Electronic Reduce Output (75%)	77	Tandem wired
4	F32T8	1	ELECT RO	Electronic Reduce Output (75%)	100	
4	F32T8	2	ELECT RO	Electronic Reduce Output (75%)	102	(2) two-lamp ballasts
2	F32T8	1	ELECT TL	Electronic Two Level (50 & 100%)	65	
3	F32T8	1.5	ELECT TL	Electronic Two Level (50 & 100%)	98	Tandem wired
4	F32T8	2	ELECT TL	Electronic Two Level (50 & 100%)	130	(2) two-lamp ballasts
2	F32T8	1	ELECT AO	Electronic Adjustable Output (to 15%)	73	
3	F32T8	1.5	ELECT AO	Electronic Adjustable Output (to 15%)	110	Tandem wired
4	F32T8	2	ELECT AO	Electronic Adjustable Output (to 15%)	146	(2) two-lamp ballasts
2	F32T8	1	ELECT DIM	Electronic Dimming (to 1%)	75	
3	F32T8	1.5	ELECT DIM	Electronic Dimming (to 1%)	113	Tandem wired
4	F32T8	2	ELECT DIM	Electronic Dimming (to 1%)	150	(2) two-lamp ballasts
5 foot Fluorescent Rapid Start (40W)						
1	F40T8	1	MAG EE	Magnetic Energy Efficient	50	
2	F40T8	1	MAG EE	Magnetic Energy Efficient	92	
1	F40T8	1	ELECT	Electronic	46	
2	F40T8	1	ELECT	Electronic	79	
3	F40T8	2	ELECT	Electronic	109	
3 foot Fluorescent Rapid Start Energy-Saving (25W)						
1	F30T12/ES	1	MAG STD	Magnetic Standard	42	
2	F30T12/ES	1	MAG STD	Magnetic Standard	74	
3	F30T12/ES	1.5	MAG STD	Magnetic Standard	111	Tandem wired
3	F30T12/ES	2	MAG STD	Magnetic Standard	116	
2	F30T12/ES	1	MAG EE	Magnetic Energy Efficient	66	
1	F30T12/ES	1	ELECT	Electronic	26	
2	F30T12/ES	1	ELECT	Electronic	53	

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
3 foot Fluorescent Rapid Start Standard (30W)						
1	F30T12	1	MAG STD	Magnetic Standard	46	
2	F30T12	1	MAG STD	Magnetic Standard	79	
3	F30T12	1.5	MAG STD	Magnetic Standard	118	Tandem wired
3	F30T12	2	MAG STD	Magnetic Standard	125	
4 foot Fluorescent Rapid Start Energy-Saving Plus (32W)						
1	F40T12/ES Plus	0.5	MAG EE	Magnetic Energy Efficient	34	Tandem wired
1	F40T12/ES Plus	1	MAG EE	Magnetic Energy Efficient	41	
2	F40T12/ES Plus	1	MAG EE	Magnetic Energy Efficient	68	
3	F40T12/ES Plus	1	MAG EE	Magnetic Energy Efficient	99	
3	F40T12/ES Plus	1.5	MAG EE	Magnetic Energy Efficient	102	Tandem wired
3	F40T12/ES Plus	2	MAG EE	Magnetic Energy Efficient	109	
4	F40T12/ES Plus	2	MAG EE	Magnetic Energy Efficient	136	(2) Two-lamp ballasts
4 foot Fluorescent Rapid Start Energy-Saving (34W)						
1	F40T12/ES	0.5	MAG STD**	Magnetic Standard	42	Tandem wired
1	F40T12/ES	1	MAG STD**	Magnetic Standard	48	
2	F40T12/ES	1	MAG STD**	Magnetic Standard	82	
3	F40T12/ES	1.5	MAG STD**	Magnetic Standard	122	Tandem wired
3	F40T12/ES	2	MAG STD**	Magnetic Standard	130	
4	F40T12/ES	2	MAG STD**	Magnetic Standard	164	(2) Two-lamp ballasts
1	F40T12/ES	0.5	MAG EE	Magnetic Energy Efficient	36	Tandem wired
1	F40T12/ES	1	MAG EE	Magnetic Energy Efficient	43	
2	F40T12/ES	1	MAG EE	Magnetic Energy Efficient	72	
3	F40T12/ES	1	MAG EE	Magnetic Energy Efficient	105	
3	F40T12/ES	1.5	MAG EE	Magnetic Energy Efficient	108	Tandem wired
3	F40T12/ES	2	MAG EE	Magnetic Energy Efficient	112	
4	F40T12/ES	2	MAG EE	Magnetic Energy Efficient	144	(2) Two-lamp ballasts
2	F40T12/ES	1	MAG HC	Magnetic Heater Cutout	58	
3	F40T12/ES	1.5	MAG HC	Magnetic Heater Cutout	87	Tandem wired
4	F40T12/ES	2	MAG HC	Magnetic Heater Cutout	116	(2) Two-lamp ballasts
2	F40T12/ES	1	MAG HC FO	Mag. Heater Cutout Full Light	66	
3	F40T12/ES	1.5	MAG HC FO	Mag. Heater Cutout Full Light	99	Tandem wired
4	F40T12/ES	2	MAG HC FO	Mag. Heater Cutout Full Light	132	(2) Two-lamp ballasts

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
4 foot Fluorescent Rapid Start Energy-Saving (34W) (cont.)						
1	F40T12/ES	0.5	ELECT	Electronic	30	Tandem wired
1	F40T12/ES	1	ELECT	Electronic	31	
2	F40T12/ES	1	ELECT	Electronic	62	
3	F40T12/ES	1	ELECT	Electronic	90	
3	F40T12/ES	1.5	ELECT	Electronic	93	Tandem wired
3	F40T12/ES	2	ELECT	Electronic	93	
4	F40T12/ES	1	ELECT	Electronic	121	
4	F40T12/ES	2	ELECT	Electronic	124	(2) Two-lamp ballasts
2	F40T12/ES	1	ELECT AO	Elec. Adjustable Output (to 15%)	60	
3	F40T12/ES	1.5	ELECT AO	Elec. Adjustable Output (to 15%)	90	Tandem wired
4	F40T12/ES	2	ELECT AO	Elec. Adjustable Output (to 15%)	120	(2) Two-lamp ballasts
4 foot Fluorescent Rapid Start Standard (40W)						
1	F40T12	0.5	MAG STD**	Magnetic Standard	26	Tandem wired
1	F40T12	1	MAG STD**	Magnetic Standard	52	
2	F40T12	1	MAG STD**	Magnetic Standard	96	
3	F40T12	1.5	MAG STD**	Magnetic Standard	144	Tandem wired
3	F40T12	2	MAG STD**	Magnetic Standard	148	
4	F40T12	2	MAG STD**	Magnetic Standard	192	(2) Two-lamp ballasts
1	F40T12	0.5	MAG EE	Magnetic Energy Efficient	44	Tandem wired
1	F40T12	1	MAG EE	Magnetic Energy Efficient	46	
2	F40T12	1	MAG EE	Magnetic Energy Efficient	88	
3	F40T12	1	MAG EE	Magnetic Energy Efficient	127	
3	F40T12	1.5	MAG EE	Magnetic Energy Efficient	132	Tandem wired
3	F40T12	2	MAG EE	Magnetic Energy Efficient	134	
4	F40T12	2	MAG EE	Magnetic Energy Efficient	176	(2) Two-lamp ballasts
2	F40T12	1	MAG HC	Magnetic Heater Cutout	71	
3	F40T12	1.5	MAG HC	Magnetic Heater Cutout	107	Tandem wired
4	F40T12	2	MAG HC	Magnetic Heater Cutout	142	(2) Two-lamp ballasts

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
4 foot Fluorescent Rapid Start Standard (40W) (cont.)						
2	F40T12	1	MAG HC FO	Magnetic Heater Cutout Full Light	80	
3	F40T12	1.5	MAG HC FO	Magnetic Heater Cutout Full Light	120	Tandem wired
4	F40T12	2	MAG HC FO	Magnetic Heater Cutout Full Light	160	(2) Two-lamp ballasts
1	F40T12	0.5	ELECT	Electronic	36	Tandem wired
1	F40T12	1	ELECT	Electronic	37	
2	F40T12	1	ELECT	Electronic	72	
3	F40T12	1	ELECT	Electronic	107	
3	F40T12	1.5	ELECT	Electronic	108	Tandem wired
3	F40T12	2	ELECT	Electronic	109	
4	F40T12	1	ELECT	Electronic	135	
4	F40T12	2	ELECT	Electronic	144	(2) Two-lamp ballasts
2	F40T12	1	ELECT RO	Electronic Reduce Output (75%)	61	
3	F40T12	1	ELECT RO	Electronic Reduce Output (75%)	90	
3	F40T12	1.5	ELECT RO	Electronic Reduce Output (75%)	92	Tandem wired
4	F40T12	2	ELECT RO	Electronic Reduce Output (75%)	122	(2) Two-lamp ballasts
2	F40T12	1	ELECT TL	Elec. Two Level (50 & 100%)	69	
3	F40T12	1.5	ELECT TL	Elec. Two Level (50 & 100%)	104	Tandem wired
4	F40T12	2	ELECT TL	Elec. Two Level (50 & 100%)	138	(2) Two-lamp ballasts
2	F40T12	1	ELECT AO	Elec. Adjustable Output (to 15%)	73	
3	F40T12	1.5	ELECT AO	Elec. Adjustable Output (to 15%)	110	Tandem wired
4	F40T12	2	ELECT AO	Elec. Adjustable Output (to 15%)	146	(2) Two-lamp ballasts
2	F40T12	1	ELECT DIM	Electronic Dimming (to 1%)	83	
3	F40T12	1.5	ELECT DIM	Electronic Dimming (to 1%)	125	Tandem wired
4	F40T12	2	ELECT DIM	Electronic Dimming (to 1%)	166	(2) Two-lamp ballasts

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
4 foot Fluorescent Rapid Start Extended Output (42W)						
2	F40T10/EO	1	MAG EE	Magnetic Energy Efficient	92	
3	F40T10/EO	1.5	MAG EE	Magnetic Energy Efficient	138	Tandem wired
4	F40T10/EO	2	MAG EE	Magnetic Energy Efficient	184	(2) Two-lamp ballasts
2	F40T10/EO	1	MAG HC	Magnetic Heater Cutout	74	
3	F40T10/EO	1.5	MAG HC	Magnetic Heater Cutout	111	Tandem wired
4	F40T10/EO	2	MAG HC	Magnetic Heater Cutout	148	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT	Electronic	74	
3	F40T10/EO	1.5	ELECT	Electronic	111	Tandem wired
4	F40T10/EO	2	ELECT	Electronic	148	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT RO	Electronic Reduce Output (75%)	63	
3	F40T10/EO	1.5	ELECT RO	Electronic Reduce Output (75%)	95	Tandem wired
4	F40T10/EO	2	ELECT RO	Electronic Reduce Output (75%)	126	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT TL	Elec. Two Level (50 & 100%)	72	
3	F40T10/EO	1.5	ELECT TL	Elec. Two Level (50 & 100%)	108	Tandem wired
4	F40T10/EO	2	ELECT TL	Elec. Two Level (50 & 100%)	144	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT AO	Elec. Adjustable Output (to 15%)	73	
3	F40T10/EO	1.5	ELECT AO	Elec. Adjustable Output (to 15%)	110	Tandem wired
4	F40T10/EO	2	ELECT AO	Elec. Adjustable Output (to 15%)	146	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT DIM	Electronic Dimming (to 1%)	85	
3	F40T10/EO	1.5	ELECT DIM	Electronic Dimming (to 1%)	128	Tandem wired
4	F40T10/EO	2	ELECT DIM	Electronic Dimming (to 1%)	170	(2) Two-lamp ballasts

Table B-11–Luminaire Power (continued)

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
8 foot Fluorescent Rapid Start High Output Energy-Saving (86W)						
2	F96T8/HO	1	ELECT	Electronic	160	
8 foot Fluorescent Rapid Start High Output Energy-Saving (95W)						
1	F96T12/HO/ES	1	MAG STD	Magnetic Standard	125	
2	F96T12/HO/ES	1	MAG STD**	Magnetic Standard	227	
2	F96T12/HO/ES	1	MAG EE	Magnetic Energy Efficient	208	
4	F96T12/HO/ES	2	MAG EE	Magnetic Energy Efficient	416	(2) Two-lamp ballasts
2	F96T12/HO/ES	1	ELECT	Electronic	160	
4	F96T12/HO/ES	2	ELECT	Electronic	320	(2) Two-lamp ballasts
8 foot Fluorescent Rapid Start High Output (110W)						
1	F96T12/HO	1	MAG STD	Magnetic Standard	140	
2	F96T12/HO	1	MAG STD**	Magnetic Standard	252	
2	F96T12/HO	1	MAG EE	Magnetic Energy Efficient	237	
4	F96T12/HO	2	MAG EE	Magnetic Energy Efficient	474	(2) Two-lamp ballasts
2	F96T12/HO	1	ELECT	Electronic	190	
4	F96T12/HO	2	ELECT	Electronic	380	(2) Two-lamp ballasts
8 foot Fluorescent Rapid Start Very High Output Energy-Saving (195W)						
1	F96T12/VHO/ES	1	MAG STD	Magnetic Standard	200	
2	F96T12/VHO/ES	1	MAG STD	Magnetic Standard	325	
4	F96T12/VHO/ES	2	MAG STD	Magnetic Standard	650	(2) Two-lamp ballasts
8 foot Fluorescent Rapid Start Very High Output (215W)						
1	F96T12/VHO	1	MAG STD	Magnetic Standard	230	
2	F96T12/VHO	1	MAG STD	Magnetic Standard	440	
4	F96T12/VHO	2	MAG STD	Magnetic Standard	880	

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
4 foot Fluorescent Slimline Energy-Saving T12 (32W)						
1	F48T12/ES	1	MAG STD	Magnetic Standard	51	
2	F48T12/ES	1	MAG STD	Magnetic Standard	82	
4 foot Fluorescent Slimline Standard T12 (39W)						
1	F48T12	1	MAG STD	Magnetic Standard	59	
2	F48T12	1	MAG STD	Magnetic Standard	98	
8 foot Fluorescent Instant Start T8 (Slimline with Rare Earth Phosphors)						
1	F96T8	1	ELECT	Electronic	71	
2	F96T8	1	ELECT	Electronic	115	
8 foot Fluorescent Slimline Energy-Saving (60W)						
1	F96T12/ES	1	MAG STD	Magnetic Standard	83	
2	F96T12/ES	1	MAG STD**	Magnetic Standard	138	
2	F96T12/ES	1	MAG EE	Magnetic Energy Efficient	123	
4	F96T12/ES	2	MAG EE	Magnetic Energy Efficient	246	(2) Two-lamp ballasts
2	F96T12/ES	1	ELECT	Electronic	105	
4	F96T12/ES	2	ELECT	Electronic	210	(2) Two-lamp ballasts
8 foot Fluorescent Slimline Standard (75W)						
1	F96T12	1	MAG STD	Magnetic Standard	100	
2	F96T12	1	MAG STD**	Magnetic Standard	173	
2	F96T12	1	MAG EE	Magnetic Energy Efficient	158	
4	F96T12	2	MAG EE	Magnetic Energy Efficient	316	(2) Two-lamp ballasts
2	F96T12	1	ELECT	Electronic	130	
4	F96T12	2	ELECT	Electronic	260	(2) Two-lamp ballasts
2	F96T12	1	ELECT IS	Electronic Instant Start	130	
3	F96T12	1.5	ELECT IS	Electronic Instant Start	195	Tandem wired
4	F96T12	2	ELECT IS	Electronic Instant Start	260	(2) Two-lamp ballasts

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
Mercury Vapor						
1	MV40	1	MAG STD	Magnetic Standard	51	
1	MV50	1	MAG STD	Magnetic Standard	63	
1	MV75	1	MAG STD	Magnetic Standard	88	
1	MV100	1	MAG STD	Magnetic Standard	119	
1	MV175	1	MAG STD	Magnetic Standard	197	
1	MV250	1	MAG STD	Magnetic Standard	285	
1	MV400	1	MAG STD	Magnetic Standard	450	
1	MV1000	1	MAG STD	Magnetic Standard	1080	
Metal Halide						
1	MH32	1	MAG STD	Magnetic Standard	42	
1	MH70	1	MAG STD	Magnetic Standard	95	
1	MH100	1	MAG STD	Magnetic Standard	142	
1	MH175	1	MAG STD	Magnetic Standard	210	
1	MH250	1	MAG STD	Magnetic Standard	295	
1	MH400	1	MAG STD	Magnetic Standard	461	
1	MH1000	1	MAG STD	Magnetic Standard	1080	
High Pressure Sodium						
1	HPS35	1	MAG STD	Magnetic Standard	44	
1	HPS50	1	MAG STD	Magnetic Standard	61	
1	HPS70	1	MAG STD	Magnetic Standard	93	
1	HPS100	1	MAG STD	Magnetic Standard	116	
1	HPS150	1	MAG STD	Magnetic Standard	173	
1	HPS200	1	MAG STD	Magnetic Standard	240	
1	HPS250	1	MAG STD	Magnetic Standard	302	
1	HPS400	1	MAG STD	Magnetic Standard	469	
1	HPS1000	1	MAG STD	Magnetic Standard	1090	
Low Pressure Sodium						
1	LPS18	1	MAG STD	Magnetic Standard	30	
1	LPS35	1	MAG STD	Magnetic Standard	60	
1	LPS55	1	MAG STD	Magnetic Standard	80	
1	LPS90	1	MAG STD	Magnetic Standard	125	
1	LPS135	1	MAG STD	Magnetic Standard	178	
1	LPS180	1	MAG STD	Magnetic Standard	220	

Table B-11–Luminaire Power (continued)

LUMINAIRE POWER

Lamp No.	Lamp Designation	Ballast No.	Ballast Abbreviation	Ballast Description	Watts/ Luminaire	Comments
12 Volt Tungsten Halogen, MR 16 & Electronic Transformer						
1	Q20MR16(12V)	1	ELECT	Electronic	23	
1	Q35MR16(12V)	1	ELECT	Electronic	39	
1	Q50MR16(12V)	1	ELECT	Electronic	55	
1	Q70MR16(12V)	1	ELECT	Electronic	78	

*** US Energy Policy Act of 1992 affect on lamps**
Beginning in April 1994, many common wattage lamp types can no longer be manufactured or imported into the U.S. Federal Energy Legislation has decreed that these lamp types must be eliminated to reduce energy consumption. Lamp Types affected include the following fluorescent lamps:

Fluorescent Lamps	F40U/3 Cool White	F96T12/	W
F40 CW	F40U/3 Warm White	F96T12/	WW
F40 D	F40U/6 Cool White	F96T12/	WWX
F40 D/WM	F40U/6 Warm White Deluxe	F96T12/	WWX/WM
F40 W	F40U/6 Warm White	F96T12/	HO/D
F40 WW	F96T12/ CW	F96T12/	HO/CW
F40 WWX	F96T12/ D	F96T12/	HO/W
F40 WWX/WM	F96T12/ D/WM	F96T12/	HO/WW

Incandescent PAR Lamps		Inc. Reflector Lamps	
75PAR38	150PAR38	75R40	200R40
75/65PAR38	150/120PAR38	75R30	
100/80PAR38		150R40	
100 PAR38		100R40	

**** US National Appliance Energy Conservation Act of 1988 affect on ballasts**
In 1991 using the following Standard Magnetic ballasts was not permitted in the US.

- -Single and two-lamp ballasts for 4' T12 Rapid Start Lamps, 120V & 277V 60Hz
- -Two-lamp ballasts for 8' T-12 Slimline lamps
- -Two-lamp ballasts for 8' T12 high-output rapid start lamps

Table B-12– Solar Heat Gain Coefficient Compliance

ALTERNATIVE CALCULATION METHOD For Nonresidential Buildings- Solar Heat Gain Coefficient Compliance

APPLICABLE STANDARD: Energy Efficiency Standards for Nonresidential Buildings

AUDIENCE: Building Officials, Architects, Engineers, Designers and Energy Documentation Consultants
EFFECTIVE DATE: July 1, 1999
AVAILABILITY: July 1, 1999
LEVEL OF CHANGE: Optional

Summary:
The California Energy Commission approved a new Alternative Calculation Method (ACM) for energy consultants, designers, architects, and builders to demonstrate compliance with Solar Heat Gain Coefficient (SHGC) values required by the Efficiency Standards for Nonresidential Buildings. This method specifically applies to fenestration products, including glass and frame, that do not have SHGC values published by the National Fenestration Rating Council (NFRC) in their Certified Products Directory. For information on other shading alternatives and how to apply the results of this calculation method, see the *1998 Nonresidential Manual*.
Recently the Energy Commission updated the regulations for 1998 nonresidential buildings to express the shading requirements for fenestration products in terms of SHGC of the entire product, including frame. This update only allowed use of the default SHGC for products without certified SHGC values. The SHGC values in the Energy Commission's default table are intended to be conservative and do not represent the types of products typically used in a large portion of nonresidential construction. The majority of products typically used also do not have SHGC values published by NFRC and cannot be used with the 1998 standards unless the Commission provides an alternative calculation method for determining compliance.
This alternative calculation methodology expands available shading alternatives by providing a method to use the SHGC for the glass alone, which can be used to determine compliance for manufactured, site-assembled, and field-fabricated fenestration products. Instructions are separately provided below for Prescriptive or Performance compliance approaches along with a description of responsibilities for energy consultants/designers/architects, builders, installers, and building department plan and field inspectors.

Compliance Using the Prescriptive and Performance Approach

Site-Assembled Fenestration Products and Field-fabricated Fenestration
This section describes the alternative calculation method for determining compliance for site-assembled and field-fabricated products.
Site-assembled fenestration includes both field-fabricated fenestration and fenestration whose frame is previously cut or formed by a manufacturer with the specific intention of being used with a glass assembly to create a complete fenestration product. Field-fabricated fenestration is a fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product.
Use the following equation to calculate the shading value for fenestration that is used to determine compliance. Convert the center of glass shading value, $SHGC_c$, from the manufacturer's documentation to a shading value for the fenestration product including framing,

$SHGC_{fen,}$
$$\mathbf{SHGC_{fen} = 0.08 + 0.86 \times SHGC_c}$$
Where:

$SHGC_c$ is the SHGC for the center of glass alone, and $SHGC_{fen}$ is the SHGC for the fenestration including glass and frame.

Manufactured Fenestration Products

This section describes the alternative calculation method for determining compliance for manufactured products that do not have SHGC values published by the National Fenestration Rating Council (NFRC) in their Certified Products Directory.

Manufactured Fenestration Products without a SHGC certified to National Fenestration Rating Council, NFRC, are similar to those that have a SHGC certified to NFRC. They are complete products, shipped from the manufacturer with the frame and glazing already assembled. These products may be listed in the *NFRC Certified Products Directory* with their U-factor, but not with a SHGC. To determine compliance with the building efficiency standards the center of glass SHGC from the manufacturer's documentation for the proposed glazing must be converted to an SHGC for the fenestration that includes the framing effect.

Use the following equation to calculate the shading value for fenestration that is used to determine compliance. Convert the center of glass shading value, $SHGC_c$ from the manufacturer's documentation to a shading value for the fenestration product including framing, $SHGC_{fen,}$

$SHGC_{fen} = 0.11 + 0.81 \times SHGC_c$

Where:

$SHGC_c$ is the SHGC for the center of glass alone, and

$SHGC_{fen}$ is the SHGC for the fenestration including glass and frame.

Solar Heat Gain Coefficient (SHGC)

Responsibilities for Compliance

This section describes the responsibilities of energy consultants, designers, architects, builders, installers, and building departments when determining compliance with SHGC requirements.

Energy Consultants, Designers, Architects

Products with SHGCs Certified to NFRC

SHGCs can be found in the NFRC *Certified Products Directory,* SV section. Contact NFRC at 301-589-6372 for a copy of the directory or go to NFRC's website at www.nfrc.org for an online database of the directory.

Field-Fabricated Fenestration, Site-Assembled Fenestration and Fenestration Products without SHGC Certified to NFRC

The procedure described below does not apply to site-assembled vertical glazing in buildings with (a) 100,000 sf or more of conditioned floor area and (b) 10,000 sf or more of vertical fenestration area. For these glazing assemblies, use the NFRC 100SB Label Certificate procedure described above. (For projects where the building has 100,000 sf or more of conditioned space and 10,000 sf or more of vertical fenestration area, the SHGC of the vertical glazing must be obtained using NFRC 100SB and must be verified by a Label Certificate for Site-Built Products. The Label Certificate must be included with the plans or be provided on site at the time of inspection.)

To determine compliance with the efficiency standards, the center of glass SHGC from the manufacturer's documentation for the proposed glazing must be converted to an $SHGC_{fen}$ for the fenestration that includes the framing effect. For the Prescriptive compliance method, the $SHGC_{fen}$ is then entered into the prescriptive ENV-1 form, Part 2 of 2 and must appear on the plans.

For the Performance compliance method, the $SHGC_{fen}$ output information printed on the Performance ENV-1 form must be listed on the building plans. The PERF-1 and Performance

ENV-1 forms must appear on the plans. The building plan window schedule list must indicate the proposed total $SHGC_{fen}$ values for each fenestration assembly, and these values must be equal to the SHGCs listed on the Performance ENV-1 computer form. (Note: an under-calculation of space conditioning energy can result from entering either too low or too high an $SHGC_{fen}$ for the product.) The proposed design $SHGC_{fen}$ values are entered into the computer program to automatically generate the energy budget of the standard design and the energy use of the proposed design. The building complies if the total energy use of the proposed design is the same or less than the standard design energy budget.
Permit applications must include heat gain documentation for the Building Plan Checker. This documentation must include a copy of the manufacturer's documentation showing the $SHGC_c$, center of glass alone and the calculation used to determine the $SHGC_{fen}$. If the proposed design uses multiple fenestration products or site-assembled fenestration products, a calculation for each different $SHGC_{fen}$ must be attached to the plans along with each glass unit manufacturer's documentation.

Mixed Fenestration Types

If mixed fenestration is included in the compliance analysis, then the compliance submittal must demonstrate which are certified fenestration products and which are non-certified fenestration or site-assembled fenestration products. The manufacturer's documentation and calculations for each product must be included in the submittal, and either the ENV-1 or PERF-1 form must be included on the building plans.

Builder and Installer Responsibilities

The builder is responsible for assuring that the glass documentation showing the SHGC used for determining compliance is provided to the installer. The builder is responsible for obtaining an NFRC Label Certificate for Site-Built Products for the building's vertical glazing if the building is 100,000 sf or more and has 10,000 sf or more of vertical glazing.

The builder is also responsible for assuring that the persons preparing compliance documentation are specifying products that the builder intends to install. The builder must assure that the glazing contractor installs the glass with the same $SHGC_c$ as used for compliance and that the building inspector is provided with manufacturers' documentation showing the $SHGC_c$ for the actual glass product installed. The builder should verify that these fenestration products are clearly shown on the building plans before fenestration products are purchased and installed.

Building Department Responsibilities - Plan Checker

The building department plan checker is responsible for assuring that the plans identify which fenestration is site-assembled and which is not. The plan-checker is responsible for verifying that the $SHGC_{fen}$ and $SHGC_c$ for non-certified fenestration products or site-assembled products is identified on the plans, that calculations have been provided showing the conversion from $SHGC_c$ to $SHGC_{fen}$, and that manufacturer documentation of the $SHGC_c$ has been provided for the fenestration to be installed. Plans should be consistent with the compliance documentation, the calculations showing the conversion from $SHGC_c$ to $SHGC_{fen}$, and Prescriptive ENV-1 Part 2 of 2 or Performance ENV-1.

Building Inspector

The building department field inspector is responsible for assuring that manufacturer's documentation has been provided for the installed fenestration. The inspector is responsible for checking the NFRC label for manufactured fenestration products, or the NFRC 100SB Label Certificate for site-built products where appropriate as described below [see "Energy Consultants, Designers, Architects: Products with SHGCs Certified to NFRC" above].
All manufactured fenestration products must have either an NFRC label or manufacturer's label with default SHGCs from Table 1-E.
All site-assembled fenestration products in buildings 100,000 sf of conditioned floor area or more and 10,000 sf of vertical fenestration area or more must have either an NFRC Label Certificate for

Site-Built Fenestration Products or a manufacturer's certificate with a default SHGC from Table 1-E.

Site-assembled vertical fenestration products in buildings less than 100,000 sf, or buildings with less than 10,000 sf of vertical glazing, may use either of the rating/labeling methods described in (b) above, or the $SHGC_{fen}$ calculation method described in this section.

Horizontal glazing that does not have a certified NFRC SHGC may use any of the above methods for determining and labeling or certifying the SHGC.

The field inspector is responsible for assuring that the certified SHGC, or $SHGC_c$ and $SHGC_{fen}$, for the installed fenestration is consistent with the plans, the Prescriptive ENV-1 Part 2 of 2 or the Performance PERF-1 and Performance ENV-1, and that manufacturer documentation is consistent with the product installed in the building. Plans shall indicate which fenestration is site-assembled or is a fenestration product without SHGCs certified to the NFRC.

Thermal Transmittance (U-Factor)

Responsibilities for Compliance

This section describes the responsibilities of energy consultants, designers, architects, builders, installers, and building departments when determining U-factor compliance.

Table I-1 provides default U-factors for skylights and site-built fenestration in buildings covered by the Nonresidential Energy Standards. The default table may be used only for the following:

Site-assembled and field-fabricated glazed wall systems in buildings covered by the Nonresidential Energy Standards that have less than 100,000 square feet of conditioned floor area or less than 10,000 square feet of vertical glazing.

Skylights in buildings covered by the Nonresidential Energy Standards.

The default Table I-1 is consistent with default U-factors published in Table 5, Chapter 29, ASHRAE Fundamentals Handbook, 1997, which is referenced in the Energy Standards.

Fenestration products fitting the two descriptions above may still use U-factors obtained through NFRC if available.

Responsibilities for Compliance

This section describes the responsibilities of energy consultants, designers, architects, builders, installers, and building departments when Table I-1 is used for determining compliance with the U-factor requirements of the Efficiency Standards.

Energy Consultants, Designers, Architects

Products with U-Factor Certified to NFRC

U-factor values can be found in the *NFRC Certified Products Directory.* Contact NFRC at 301-589-6372 for a copy of the directory or go to NFRC's website at www.nfrc.org for an online database of the directory.

Field-Fabricated Fenestration, Site-Assembled Fenestration and Fenestration Products without U-factor Certified to NFRC

To determine compliance with the efficiency standards, the Glazing Type and Frame Type shown in Table I-1 must be identified from the manufacturer's documentation for the proposed glazing.

For the Prescriptive compliance method, the U-factor must be selected from Table I-1 for this Glazing Type and Frame Type and entered into the prescriptive ENV-1 form, Part 2 of 2, and must appear on the plans.

For the Performance compliance method, the U-factor output information printed on the Performance ENV-1 form must be listed on the building plans. The PERF-1 and Performance ENV-1 forms must appear on the plans. The building plan window schedule list must indicate the proposed total U-factors for each fenestration assembly, and these values must be equal to or less than the U-factors listed on the Performance ENV-1 computer form. The proposed design U-factors are entered into the computer program to automatically generate the energy use of the proposed design. The building complies if the total energy use of the proposed design is the same or less than the standard design energy budget.

Permit applications must include fenestration U-factor documentation for the Building Plan Checker. This documentation must include a copy of the manufacturer's documentation showing the Glazing Type information – number of panes, spacing of panes, glass type, gas fill type, coating emissivity and location – and the Frame Type – frame material type, presence of thermal breaks, and identification of structural glazing (glazing with no frame) that is used to determine the U-factor. If the proposed design uses multiple fenestration products or site-assembled fenestration products, manufacturer's documentation for each different U-factor must be attached to the plans for each glass unit. Manufacturer's documentation must be provided for each U-factor used for compliance.

Mixed Fenestration Types

If mixed fenestration is included in the compliance analysis, then the compliance submittal must demonstrate which are certified fenestration products and which are non-certified fenestration or site-assembled fenestration products. The manufacturer's documentation and calculations for each product must be included in the submittal, and either the ENV-1 or PERF-1 form must be included on the building plans.

Builder and Installer Responsibilities

The builder is responsible for assuring that the glass documentation showing the U-factor used for determining compliance is provided to the installer. The builder is responsible for assuring that the persons preparing compliance documentation are specifying products that the builder intends to install. The builder is also responsible for assuring that the installer installs glass with the same U-factor as used for compliance and assuring that the field inspector for the building department is provided with manufacturer's documentation showing the U-factor and method of determining U-factor for the actual fenestration product installed. The builder should verify that these fenestration products are clearly shown on the building plans before fenestration products are purchased and installed.

Building Department Responsibilities

Plan Checker

The building department plan checker is responsible for assuring that the plans identify which fenestration is site-assembled and which is not. The plan-checker is responsible for verifying that the U-factor for non-certified fenestration products or site-assembled products is identified on the plans, that Glazing Type and Frame Type and Table 1-I have been provided showing the method of determining the U-factor, and that manufacturer documentation of the U-factor has been provided for the fenestration to be installed. Plans should be consistent with the compliance documentation, the Glazing Type and Frame Type and Table I-1 values, and Prescriptive ENV-1 Part 2 of 2 or Performance ENV-1.

Building Inspector

The building department field inspector is responsible for assuring that manufacturer's documentation has been provided for the installed fenestration. The field inspector is responsible for assuring that the U-factor for the installed fenestration is consistent with the plans, the Prescriptive ENV-1 Part 2 of 2 or the Performance PERF-1, and Performance ENV-1, and that manufacturer documentation is consistent with the product installed in the building.

Plans shall indicate which fenestration is site-assembled or is a fenestration product without U-factor certified to NFRC.

Table B-13A –Complete Building Occupancy Assumptions When Lighting Plans are Submitted for the Entire Building or When Lighting Compliance is not Performed.

Occupancy Type	No. Occ./ 1000 sf	Sensible/ occ. (Btu)	Latent/ occ. (Btu)	Recept (Watts/sf)	Hot Water (Btuh/occ.)	Lighting (Watts/sf)	Vent. (cfm/sf)
Complete Building: Industrial Storage	5	268	403	0.43	108	0.7	0.15
Complete Building: Grocery	29	252	225	0.91	113	1.5	0.23
Complete Building: Industrial Work							
High Bay	7	375	625	1.00	120	1.2	0.15
Low Bay	7	375	625	1.00	120	1.0	0.15
Complete Building: Medical	10	250	213	1.18	110	1.2	0.15
Complete Building: Office	10	250	206	1.34	106	1.2	0.15
Complete Building: Other	10	250	200	1.00	120	0.6	0.15
Complete Building: Religious							
Worship, Auditorium, Convention	136	245	112	0.96	57	1.8	1.03
Complete Building: Restaurant	45	274	334	0.79	366	1.2	0.38
Complete Building: Retail/Wholesale	29	252	224	0.94	116	1.7	0.23
Complete Building: School	40	246	171	1.00	108	1.4	0.32
Complete Building: Theater	130	268	403	0.54	60	1.3	0.98
Complete Building: Unknown	10	250	200	1.00	120	1.2	0.15

Table B-13B –Area Category Occupancy Assumptions When Lighting Plans are Submitted for Portions or for the Entire Building or When Lighting Compliance is not Performed.

Occupancy Type	*No. Occ./ 1000 sf*	*Sensible/ occ. (Btu)*	*Latent/ occ. (Btu)*	*Recept (Watts/ sf)*	*Hot Water (Btuh/ occ.)*	*Lighting (Watts/ sf)*	*Vent (cfm/ sf)*
All Others	10	250	200	1.00	120	0.6	0.15
Auditorium	143	245	105	1.00	60	2.0	1.07
Auto Repair Workshop	10	275	475	1.00	120	1.2	1.50
Bank/Financial Institution	10	250	250	1.50	120	1.4	0.15
Bar/Cocktail Lounge/Casino	67	275	275	1.00	120	1.1	1.50
Barber & Beauty Shop	10	250	200	2.00	120	1.0	0.40
Classroom	50	245	155	1.00	120	1.6	0.38
Courtrooms	25	250	200	1.50	120	1.1	0.19
Commercial/Industrial Storage	3	275	475	0.20	120	0.6	0.15
Comm./Ind. Work-General High Bay	10	275	475	1.00	120	1.2	0.15
Comm./Ind. Work-General Low Bay	10	275	475	1.00	120	1.0	0.15
Commercial/Ind. Work-Precision	10	250	200	1.00	120	1.5	0.15
Convention/Conference/ Meeting Center	67	245	155	1.00	60	1.6	0.50
Corridor/Restroom and Support Area	10	250	250	0.20	0	0.6	0.15
Dining Area	67	275	275	0.50	385	1.1	0.50
Dry Cleaning (Coin)	10	250	250	3.00	120	1.0	0.30
Dry Cleaning (Full)	10	250	250	3.00	120	1.0	0.45
Electrical and Mechanical Room	3	250	250	0.20	0	0.7	0.15
Exercising Centers and Gymnasium	20	255	875	0.50	120	1.0	0.15
Exhibit Display Area and Museum	67	250	250	1.50	60	2.0	0.50
Grocery Sales Area	33	250	200	1.00	120	1.6	0.25
High-Rise Residential	5	245	155	0.50	n/a	0.5	0.15
Hotel Function Area	67	250	200	0.50	60	2.2	0.50
Hotel/Motel Guest Room	5	245	155	0.50	2800	0.5	0.15
Kitchen and Food Preparation	5	275	475	1.50	385	1.7	0.15
Laundry	10	250	250	3.00	385	0.9	0.15
Library - Reading Areas	20	250	200	1.50	120	1.2	0.15
Library - Stacks	10	250	200	1.50	120	1.5	0.15
Lobby (Hotel)	10	250	250	0.50	120	2.2	0.15
Lobby (Main Entry and Assembly)	143	250	250	0.50	60	1.5	1.07
Lobby (Office Reception and Waiting)	10	250	250	0.50	120	1.1	0.15
Locker and Dressing Room	20	255	475	0.50	385	0.9	0.15
Mall/Arcade/Atrium	33	250	250	0.50	120	1.2	0.25
Medical/Clinical Care	10	250	200	1.50	160	1.4	0.15
Office	10	250	200	1.50	120	1.3	0.15
Police Station and Fire Station	10	250	200	1.50	120	0.9	0.15
Religious Worship	143	245	105	0.50	60	2.1	1.07

Occupancy Type	*No. Occ./ 1000 sf*	*Sensible/ occ. (Btu)*	*Latent/ occ. (Btu)*	*Recept (Watts/ sf)*	*Hot Water (Btuh/ occ.)*	*Lighting (Watts/ sf)*	*Vent (cfm/ sf)*
Retail Sales and Wholesale Showroom	33	250	200	1.00	120	2.0	0.25
Smoking Lounge	67	275	275	0.50	120	1.1	1.50
Theater (Motion Picture)	143	245	105	0.50	60	0.9	1.07
Theater (Performance)	143	245	105	0.50	60	1.4	1.07
Unknown Nonresidential	10	250	200	1.00	120	0.8	0.15

Table B-14 – Assembly U-Factors for Unlabeled Glazed Wall Systems (Site-Built Windows) and Unlabeled Skylights

Product Type		Vertical Installation				Sloped Installation						
		Unlabeled Glazed Wall Systems (Site Built Windows) (include site assembled fixed windows only, does not include operable windows)				**Unlabeled Skylight with Curb** (includes glass/plastic, flat/domed, fixed/operable)				**Unlabeled Skylight without Curb** (includes glass/plastic, flat/domed, fixed/operable)		
Frame Type		Aluminum without Thermal Break	Aluminum with Thermal Break	Wood/ Vinyl	Structural Glazing	Aluminum without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Aluminum without Thermal Break	Aluminum with Thermal Break	Structural Glazing
ID	**Glazing Type**											
	Single Glazing											
1	1/8" glass	1.22	1.11	0.98	1.11	1.98	1.89	1.75	1.47	1.36	1.25	1.25
2	1/4" acrylic/polycarb	1.08	0.96	0.84	0.96	1.82	1.73	1.60	1.31	1.21	1.10	1.10
3	1/8" acrylic/polycarb	1.15	1.04	0.91	1.04	1.90	1.81	1.68	1.39	1.29	1.18	1.18
	Double Glazing											
4	1/4" airspace	0.79	0.68	0.56	0.63	1.31	1.11	1.05	0.84	0.82	0.70	0.66
5	1/2" airspace	0.73	0.62	0.50	0.57	1.30	1.10	1.04	0.84	0.81	0.69	0.65
6	1/4" argon space	0.75	0.64	0.52	0.60	1.27	1.07	1.00	0.80	0.77	0.66	0.62
7	1/2" argon space	0.70	0.59	0.48	0.55	1.27	1.07	1.00	0.80	0.77	0.66	0.62
	Double Glazing, *e*=0.60 on surface 2 or 3											
8	1/4" airspace	0.76	0.65	0.53	0.61	1.27	1.08	1.01	0.81	0.78	0.67	0.63
9	1/2" airspace	0.69	0.58	0.47	0.54	1.27	1.07	1.00	0.80	0.77	0.66	0.62
10	1/4" argon space	0.72	0.61	0.49	0.56	1.23	1.03	0.97	0.76	0.74	0.63	0.58
11	1/2" argon space	0.67	0.56	0.44	0.51	1.23	1.03	0.97	0.76	0.74	0.63	0.58
	Double Glazing, *e*=0.40 on surface 2 or 3											
12	1/4" airspace	0.74	0.63	0.51	0.58	1.25	1.05	0.99	0.78	0.76	0.64	0.60
13	1/2" airspace	0.66	0.55	0.44	0.51	1.24	1.04	0.98	0.77	0.75	0.64	0.59
14	1/4" argon space	0.69	0.57	0.46	0.53	1.18	0.99	0.92	0.72	0.70	0.58	0.54
15	1/2" argon space	0.63	0.51	0.40	0.47	1.20	1.00	0.94	0.74	0.71	0.60	0.56
	Double Glazing, *e*=0.20 on surface 2 or 3											
16	1/4" airspace	0.70	0.59	0.48	0.55	1.20	1.00	0.94	0.74	0.71	0.60	0.56
17	1/2" airspace	0.62	0.51	0.39	0.46	1.20	1.00	0.94	0.74	0.71	0.60	0.56
18	1/4" argon space	0.64	0.53	0.42	0.49	1.14	0.94	0.88	0.68	0.65	0.54	0.50
19	1/2" argon space	0.57	0.46	0.35	0.42	1.15	0.95	0.89	0.68	0.66	0.55	0.51
	Double Glazing, *e*=0.10 on surface 2 or 3											
20	1/4" airspace	0.68	0.57	0.45	0.52	1.18	0.99	0.92	0.72	0.70	0.58	0.54
21	1/2" airspace	0.59	0.48	0.37	0.44	1.18	0.99	0.92	0.72	0.70	0.58	0.54
22	1/4" argon space	0.62	0.51	0.39	0.46	1.11	0.91	0.85	0.65	0.63	0.52	0.47
23	1/2" argon space	0.55	0.44	0.33	0.39	1.13	0.93	0.87	0.67	0.65	0.53	0.49
	Double Glazing, *e*=0.05 on surface 2 or 3											
24	1/4" airspace	0.67	0.56	0.44	0.51	1.17	0.97	0.91	0.70	0.68	0.57	0.52
25	1/2" airspace	0.57	0.46	0.35	0.42	1.17	0.98	0.91	0.71	0.69	0.58	0.53
26	1/4" argon space	0.60	0.49	0.38	0.44	1.09	0.89	0.83	0.63	0.61	0.50	0.45
27	1/2" argon space	0.53	0.42	0.31	0.38	1.11	0.91	0.85	0.65	0.63	0.52	0.47
	Triple Glazing											
28	1/4" airspaces	0.63	0.52	0.41	0.47	1.12	0.89	0.84	0.64	0.64	0.53	0.48
29	1/2" airspaces	0.57	0.46	0.35	0.41	1.10	0.87	0.81	0.61	0.62	0.51	0.45
30	1/4" argon spaces	0.60	0.49	0.38	0.43	1.09	0.86	0.80	0.60	0.61	0.50	0.44
31	1/2" argon spaces	0.55	0.45	0.34	0.39	1.07	0.84	0.79	0.59	0.59	0.48	0.42
	Triple Glazing, *e*=0.20 on surface 2,3,4, or 5											
32	1/4" airspaces	0.59	0.48	0.37	0.42	1.08	0.85	0.79	0.59	0.60	0.49	0.43
33	1/2" airspaces	0.52	0.41	0.30	0.35	1.05	0.82	0.77	0.57	0.57	0.46	0.41
34	1/4" argon spaces	0.54	0.44	0.33	0.38	1.02	0.79	0.74	0.54	0.55	0.44	0.38
35	1/2" argon spaces	0.49	0.38	0.28	0.33	1.01	0.78	0.73	0.53	0.54	0.43	0.37
	Triple Glazing, *e*=0.20 on surfaces 2 or 3 and 4 or 5											
36	1/4" airspaces	0.55	0.45	0.34	0.39	1.03	0.80	0.75	0.55	0.56	0.45	0.39
37	1/2" airspaces	0.48	0.37	0.26	0.31	1.01	0.78	0.73	0.53	0.54	0.43	0.37

Product Type		**Vertical Installation**				**Sloped Installation**						
		Unlabeled Glazed Wall Systems (Site Built Windows) (include site assembled fixed windows only, does not include operable windows)				**Unlabeled Skylight with Curb** (includes glass/plastic, flat/domed, fixed/operable)				**Unlabeled Skylight without Curb** (includes glass/plastic, flat/domed, fixed/operable)		
Frame Type		Aluminum without Thermal Break	Aluminum with Thermal Break	Wood/ Vinyl	Structural Glazing	Aluminum without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Aluminum without Thermal Break	Aluminum with Thermal Break	Structural Glazing
38	1/4" argon spaces	0.50	0.39	0.29	0.34	0.99	0.75	0.70	0.50	0.51	0.40	0.35
39	1/2" argon spaces	0.45	0.34	0.24	0.29	0.97	0.74	0.69	0.49	0.50	0.39	0.33
	Triple Glazing, *e*=0.10 on surfaces 2 or 3 and 4 or 5											
40	1/4" airspaces	0.54	0.43	0.32	0.37	1.01	0.78	0.73	0.53	0.54	0.43	0.37
41	1/2" airspaces	0.46	0.35	0.25	0.29	0.99	0.76	0.71	0.51	0.52	0.41	0.36
42	1/4" argon spaces	0.48	0.38	0.27	0.32	0.96	0.73	0.68	0.48	0.49	0.38	0.32
43	1/2" argon spaces	0.42	0.32	0.21	0.26	0.95	0.72	0.67	0.47	0.48	0.37	0.31
	Quadruple Glazing, *e*=0.10 on surfaces 2 or 3 and 4 or 5											
44	1/4" airspaces	0.49	0.38	0.28	0.33	0.97	0.74	0.69	0.49	0.50	0.39	0.33
45	1/2" airspaces	0.43	0.32	0.22	0.27	0.94	0.71	0.66	0.46	0.47	0.36	0.30
46	1/4" argon spaces	0.45	0.34	0.24	0.29	0.93	0.70	0.65	0.45	0.46	0.35	0.30
47	1/2" argon spaces	0.41	0.30	0.20	0.24	0.91	0.68	0.63	0.43	0.44	0.33	0.28
48	1/4" krypton spaces	0.41	0.30	0.20	0.24	0.88	0.65	0.60	0.40	0.42	0.31	0.25

C. California Design Location Data

The data contained in the following tables was obtained through a joint effort by the Southern California Chapter and the Golden Gate Chapter of ASHRAE. It is reprinted here with the written permission of Southern California Chapter ASHRAE, Inc.

A full listing of design location data for California is contained in the ASHRAE publication *SPCDX, Climate Data for Region X, Arizona, California, Hawaii, and Nevada* (May 1982). The publication may be ordered from:

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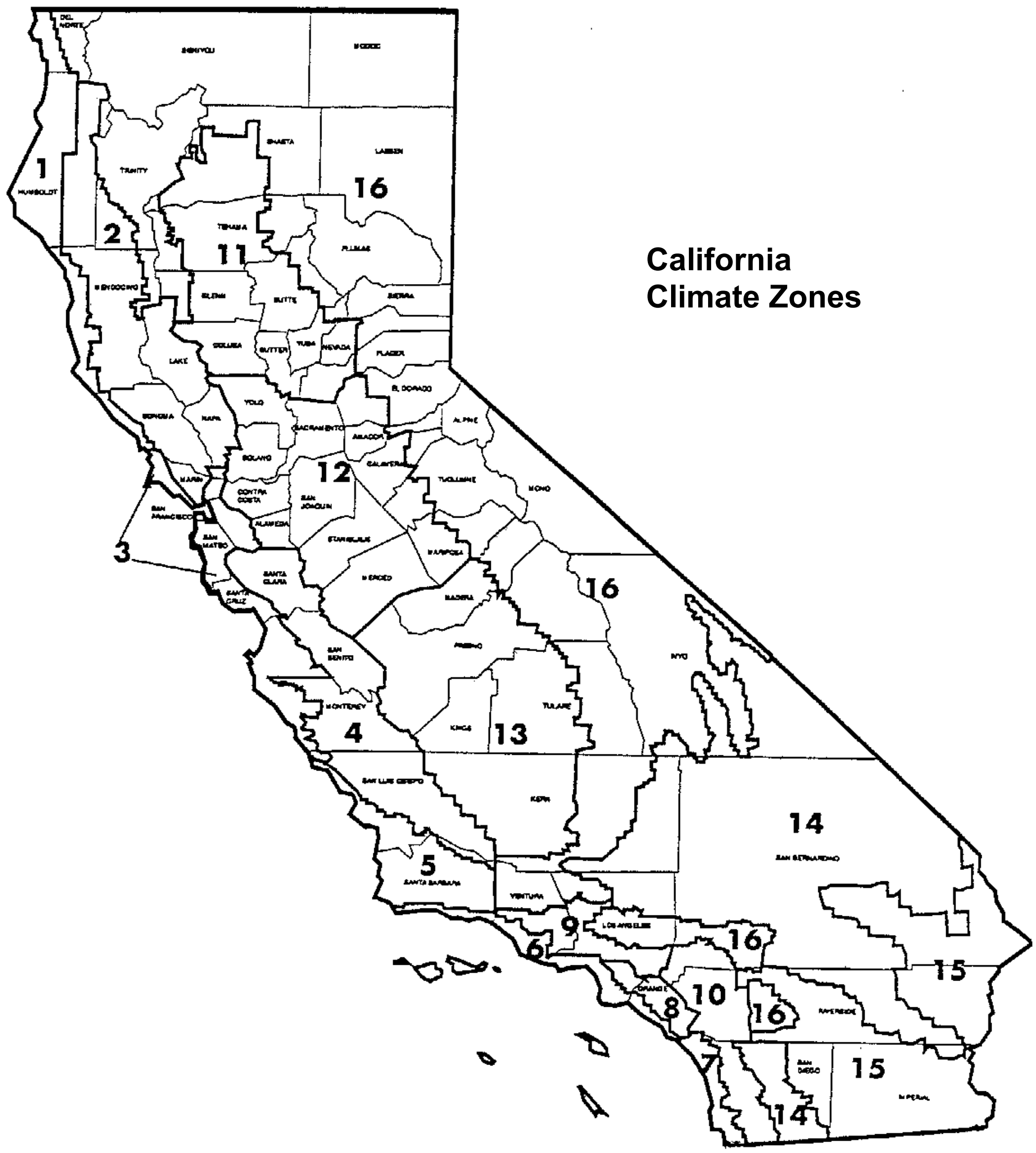
KEY TO ABBREVIATIONS:			
AFB	Air Force Base	**MCB**	Marine Corps Base
AFS	Air Force Station	**NAS**	Naval Air Station
AP	Airport	**NM**	National Monument
CO	City/County Office	**PH**	Power House
FD	Fire Department	**RS**	Ranger Station
FS	Fire Station		



California Climate Zones

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer .1% Dry Bulb	Summer .1% Wet Bulb	Summer .5% Dry Bulb	Summer .5% Wet Bulb	Summer 2% Dry Bulb	Summer 2% Wet Bulb	Summer Range	Winter Minimum	HDD
Adin RS	Modoc	16	41.20	120 57	4195	96	61	92	60	88	59	43	-7	
Alameda NAS	Alameda	3	37.79	122 19	15	88	65	82	64	76	62	21	35	2507
Alamo	Contra Costa	12	37.90	122 55	410	102	69	97	68	92	66	30	23	
Albany	Alameda	3	37.90	122 15	40	88	65	83	64	77	62	16	30	
Alderpoint	Humboldt	2	40.20	123 37	460	100	69	95	67	90	65	39	21	3424
Alhambra	Los Angeles	9	34		483	100	71	96	70	90	68	25	30	
Almaden AFS	Santa Clara	3	37.20	121 54	3470	95	62	90	60	85	59	20	20	4468
Alondra Park	Los Angeles	6	33.90		50	91	69	86	68	81	66	17	35	
Alpine	San Diego	10	32.79	116 46	1735	99	69	95	68	91	67	35	27	
Altadena	Los Angeles	9	34.20		1200	99	68	94	67	88	66	31	32	1920
Alturas RS	Modoc	16	41.5	120 33	4400	99	62	96	61	91	59	43	-10	6895
Alum Rock	Santa Clara	4	37.40	121 50	70	95	68	90	66	84	64	22	28	
Anaheim	Orange	8	33.79		158	99	69	92	68	85	67	26	32	
Anderson	Shasta	11	40.5	122 15	430	107	71	103	70	97	68	30	26	
Angwin	Napa	2	38.59	122 25	1815	98	66	93	64	88	62	33	25	
Antioch	Contra Costa	12	38	121 46	60	102	70	97	68	91	66	34	22	2627
Apple Valley	San Bernardino	14	34.5		2935	105	66	101	65	97	64	38	14	
Aptos	Santa Cruz	3	37		500	94	67	88	66	83	63	30	27	
Arcadia	Los Angeles	9	34.20		475	100	69	96	68	91	67	30	31	
Arcata	Humboldt	1	41	124 06	218	75	61	69	59	65	58	11	28	5029
Arden	Sacramento	12	38.5		80	104	70	100	69	94	67	35	28	
Arroyo Grande	San Luis	5	35.09		105	92	66	86	64	79	62	18	28	
Artesia	Los Angeles	8	33.79		50	99	71	91	70	85	68	23	33	
Arvin	Kern	13	35.20		445	106	71	102	69	98	68	30	26	
Ash Mtn	Tulare	13	36.5	118 50	1708	105	69	101	68	97	66	30	25	2703
Atascadero	San Luis	4	35.5	120 42	837	94	66	89	67	84	65	42	25	
Atherton	San Mateo	3	37.5	122 14	50	90	66	84	64	78	62	27	23	
Atwater	Merced	12	37.29		150	102	72	99	70	94	67	38	24	
Auberry	Fresno	13	37.09	119 30	2140	102	69	98	67	95	64	36	21	3313
Auburn	Placer	11	38.90	121 04	1292	103	69	100	67	95	66	33	25	3089
Avalon	Los Angeles	6	33.40	118 19	25	83	64	75	62	69	60	11	37	2204
Azusa	Los Angeles	9	34.09	118 09	605	101	70	97	69	91	68	36	31	
Baker	San Bernardino	14	35.29	116 06	940	115	73	112	72	108	70	29	23	
Bakersfield AP	Kern	13	35.40	119 03	475	106	71	102	70	98	68	34	26	2185
Balch PH	San Bernardino	14	36.90		1720	100	67	97	66	93	64	26	26	
Baldwin Park	Los Angeles	9	34		394	100	69	96	69	90	68	32	31	
Banning	Riverside	15	33.90	116 53	2349	104	69	100	68	96	67	34	20	
Barrett Dam	San Diego	10	32.70	116 40	1623	103	69	97	68	92	67	35	22	2656
Barstow	San Bernardino	14	34.90	117 02	2162	107	69	104	69	100	67	35	16	2580
Beale AFB	Yuba	11	39.09	121 26	113	105	71	102	70	97	68	34	25	2835
Beaumont	Riverside	10	33.90	116 58	2605	103	68	99	67	95	66	38	22	2628
Bell	Los Angeles	8	33.90		143	97	70	91	69	85	67	22	33	
Bell Gardens	Los Angeles	8	33.90		160	97	70	91	69	78	62	24	29	
Bellflower	Los Angeles	8	33.79		73	98	70	91	69	85	67	21	32	
Belmont	San Mateo	3	37.5		33	90	66	84	64	78	62	24	29	
Ben Lomond	Santa Cruz	3	37.09	122 06	450	92	67	85	66	79	63	30	25	
Benicia	Solano	12	38.09	122 06	55	99	69	93	67	87	65	30	28	
Berkeley	Alameda	3	37.90	122 15	345	90	64	83	63	76	61	16	33	2950
Berryessa Lake	Napa	2	38.59	122 03	480	102	70	98	69	92	67	35	26	

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer							Winter Minimum	HDD
						.1% Dry Bulb	1% Wet Bulb	.5% Dry Bulb	5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Range		
Beverly Hills	Los Angeles	9	34.09	118 10	268	94	69	88	68	83	66	20	39	
Big Bar RS	Trinity	16	40.79	121 48	1260	102	68	98	67	93	65	46	19	
Big Bear Lake	San Bernardino	16	34.20	116 53	6745	87	59	83	58	79	56	32	-3	6850
Bishop AP	Inyo	16	37.40	118 22	4108	103	61	100	60	97	58	40	5	4313
Blackwells Corner	Kern	13	35.59	119 54	644	99	68	94	66	89	65	31	23	
Bloomington	San Bernardino	10	34		980	106	71	102	70	98	69	34	30	
Blue Canyon AP	Placer	16	39.29	120 42	5280	88	60	85	59	81	57	20	13	5704
Blythe AP	Riverside	15	33.59	114 43	395	115	74	112	73	108	71	27	28	1219
Blythe CO	Riverside	15	33.59	114 36	268	115	74	112	73	108	71	27	24	1312
Boca	Nevada	16	39.40	120 06	5575	92	58	89	57	84	55	46	-18	8340
Bodie	Mono	16	38.20	119 01	8370	83	50	80	49	76	48	42	-21	
Bonita	Madera	13	32.70	117 02	105	91	69	82	67	78	64	20	28	1864
Boron AFS	Kern	14	35.09	117 35	3015	106	70	103	69	98	68	35	18	3000
Borrego Desert PK	San Diego	15	33.20	116 24	805	112	76	107	74	101	72	36	25	
Bowman Dam	Placer	11	39.40	120 39	5347	89	59	86	57	82	55	26	9	5964
Brannan Island	Sacramento	12	38.09	121 42	30	100	69	95	68	89	67	10	24	
Brawley 2 SW	Imperial	15	33	115 33	-100	113	74	110	73	105	73	32	25	1204
Brea Dam	Orange	8	33.90		275	100	69	94	68	86	66	29	30	
Bridgeport	Mono	16	38.20	119 13	6470	89	56	86	54	82	53	41	-20	
Broderick-Bryte	Yolo	12	38.59	121 30	20	104	71	100	69	94	67	36	25	
Brooks Ranch	Yolo	12	38.79	122 09	294	104	71	99	70	93	68	35	19	2968
Buena Park	Orange	8	33.90		75	98	69	92	68	85	67	25	31	
Burbank AP	Los Angeles	9	34.20	118 21	699	101	70	96	68	90	67	28	29	1701
Burbank Vly Pump	Los Angeles	9	34.20	118 21	655	101	69	96	68	90	66	28	29	1678
Burlingame	San Mateo	3	37.59	122 21	10	88	67	82	64	76	63	20	30	
Burney	Shasta	16	40.90	121 40	3127	95	64	92	63	88	61	42	0	6404
Butler Valley			40.7	123 56	420	91	66	86	64	81	62	22	20	
Buttonwillow	Kern	13	35.40	119 28	269	103	71	99	70	95	68	36	20	2621
Cabrillo NM	San Diego	7	32.70	117 14	410	89	69	84	68	80	67	12	39	
Cachuma Lake	Santa Barbara	5	34.59	119 59	781	97	69	92	67	87	65	19	26	
Calabasas	Los Angeles	9	34.20		1100	102	71	98	70	93	69	26	26	2348
Calaveras Big Trees	San Joaquin	12	38.29	120 19	4696	92	61	88	60	84	58	33	11	5848
Calexico	Imperial	15	32.70		12	114	74	110	73	106	71	28	26	
Callahan	Siskiyou	16	41.29	122 48	3185	97	63	93	62	88	60	35	7	
Calwa	Fresno	13	36.79		330	105	73	101	71	97	68	34	23	
Camarillo	Ventura	6	34.20	119 12	147	91	69	84	68	78	67	22	28	
Cambria AFS	San Luis	5	35.5	121 04	690	78	62	72	61	66	59	16	30	3646
Camp Pardee	Calaveras	12	38.20	120 51	658	106	71	103	70	98	69	36	27	2812
Camp Roberts	Monterey	4	35.79	120 45	765	106	72	101	71	95	69	45	16	2890
Campbell	Santa Clara	4	37.29	121 50	195	93	69	88	66	83	65	30	28	
Campo	San Diego	14	32.59	116 28	2630	101	67	95	66	90	66	41	16	3303
Canoga Park	Los Angeles	9	34.20	118 34	790	104	71	99	70	93	69	38	25	1884
Cantil	Kern	14	35.29	117 58	2010	111	71	107	71	103	70	32	12	
Canyon Dam	Plumas	16	40.09	121 05	4555	93	60	90	59	85	57	39	1	6834
Capitola	Santa Cruz	3	37		64	94	67	88	66	81	63	24	27	
Cardiff-by-the-Sea	San Diego	7	33		80	87	68	83	67	77	65	12	35	
Carlsbad	San Diego	7	33.20		44	87	68	83	67	77	65	10	34	
Carmel Valley	Monterey	3	36.5	121 44	425	94	68	88	66	80	65	20	25	
Carmichael	Sacramento	12	38.59	121 27	100	104	70	100	69	94	68	35	25	

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer .1% Dry Bulb	1% Wet Bulb	.5% Dry Bulb	.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Range	Winter Minimum	HDD
Carpinteria	Santa Barbara	6	34.40		385	90	69	83	67	77	65	15	30	
Carson	Los Angeles	6	33.79		60	96	69	88	68	82	66	19	33	
Castle AFB	Merced	12	37.40	120 34	188	105	71	101	70	96	69	33	24	2590
Castro Valley	Alameda	3	37.59	122 12	177	93	67	87	67	80	65	25	24	
Catheys Valley	Mariposa	12	37.40	120 03	1000	102	69	99	68	94	67	38	21	
Cecilville	Siskiyou	16	41.09	123 08	3000	95	63	89	62	84	59	44	13	
Cedarville	Modoc	16	41.5	120 10	4670	97	61	94	60	89	58	35	1	6304
Centerville PH	Butte	11	39.79	121 40	522	105	70	100	68	96	67	40	25	2895
Ceres	Stanislaus	12	37.59		90	101	72	96	70	90	67	36	24	
Cerritos	Los Angeles	8	33.90		34	99	71	92	69	85	68	23	33	
Cherry Valley Dam	Tuolumne	10	38		4765	96	62	92	61	88	59	32	9	
Cherryland	Alameda	3	37.5		100	93	67	86	66	79	64	24	26	
Chester	Plumas	16	40.29	121 14	4525	94	62	91	61	86	59	33	-3	
Chico Exp Sta	Butte	11	39.70	121 47	205	105	70	102	69	96	68	37	22	2878
China Lake	San	14	35.70	117 41	2220	112	70	108	68	104	68	33	15	2560
Chino	San Bernardino	10	34		714	104	70	100	69	94	68	35	27	
Chula Vista	San Diego	7	32.59	117 05	9	90	70	84	68	79	66	9	33	2072
Citrus Heights	Sacramento	12	38.70	121 27	138	104	71	100	70	94	68	36	24	
Claremont	Los Angeles	9	34.09	117 43	1201	101	69	97	68	91	66	34	29	2049
Clarksburg	Yolo	12	38.40	121 32	14	102	70	97	69	91	67	35	24	2971
Clearlake Highlands	Lake	2	39	122 43	1360	101	69	97	68	89	65	36	15	
Cloverdale	Sonoma	2	38.79	122 59	320	102	70	97	69	89	66	37	26	2763
Clovis	Fresno	13	36.79	119 43	404	105	72	102	70	98	68	36	22	
Coachella	Riverside	15	33.70		-76	114	74	110	73	106	73	28	25	
Coalinga	Fresno	13	36.20	120 21	671	103	70	98	70	93	69	34	23	2592
Colfax	Placer	11	39.09	120 57	2418	100	66	97	65	92	63	29	22	3424
Colton	San Bernardino	10	34.09		978	105	70	102	68	97	67	35	28	
Colusa	Colusa	11	39.20	122 01	60	103	72	100	70	94	68	36	23	2793
Commerce	Los Angeles	8	33.90		175	98	69	92	68	86	67	23	33	
Compton	Los Angeles	8	33.90	118 13	71	97	69	90	68	83	67	21	33	1606
Concord	Contra Costa	12	38	112 00	195	102	70	97	68	89	65	34	27	3035
Corcoran	Kings	13	36.09	119 42	200	106	72	102	71	98	70	36	22	2666
Corona	Riverside	10	33.90	117 34	710	104	70	100	69	92	67	35	26	1794
Coronado	San Diego	7	32.70	117 10	20	89	69	82	67	76	65	10	36	1500
Corte Madera	Marin	2	37.90		55	97	68	91	66	84	64	34	28	
Costa Mesa	Orange	6	33.70	117 53	100	88	68	81	66	73	65	16	31	1482
Covelo	Mendocino	2	39.79	123 15	1385	99	67	93	65	87	63	43	15	4179
Covina	Los Angeles	9	34.09		575	101	70	97	69	91	68	34	29	
Crescent City	Del Norte	1	41.79	124 12	40	75	61	69	59	65	58	18	28	4445
Crockett	Contra Costa	12	38	122 13	9	96	68	90	66	85	64	23	28	
Crows Landing	Stanislaus	12	37.40	121 06	140	101	70	96	68	89	66	33	23	2767
Cucamonga	San Bernardino	10	34.09		1450	103	69	99	68	93	65	31	29	
Cudahy	Los Angeles	8	33.90		130	98	70	91	69	85	67	21	33	
Culver City	Los Angeles	8	34	118 24	106	96	70	88	69	83	67	18	35	1515
Cupertino	Santa Clara	4	37.29	122 00	70	96	68	88	67	80	64	30	28	
Cuyama	Santa Barbara	4	34.90	116 35	2255	99	68	96	67	89	66	42	13	
Cuyamaca	San Diego	7	33		4650	92	64	85	62	81	59	29	11	4848
Cypress	Orange	8	33.79		75	98	70	92	69	85	67	24	31	
Daggett AP	San Bernardino	14	34.90	116 47	1915	109	68	106	68	102	66	33	21	2203

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer .1% Dry Bulb	1% Wet Bulb	.5% Dry Bulb	.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Range	Winter Minimum	HDD
Daly City	San Mateo	3	37.59	122 30	410	84	65	78	62	73	61	16	34	
Davis	Yolo	12	38.5	121 46	60	103	72	99	70	93	68	41	24	2844
De Sabla	Butte	11	39.90	121 37	2713	97	66	94	64	88	62	35	18	4237
Death Valley	Inyo	14	36.5	116 52	-194	121	77	118	76	114	74	28	27	1147
Deep Springs Clg	Inyo	16	37.5	117 59	5225	98	60	95	59	92	58	35	-3	
Deer Creek PH	Nevada	16	39.29	120 51	4455	93	61	91	60	87	58	39	10	5863
Del Aire	Los Angeles	6	34		100	91	69	84	67	79	66	15	37	
Delano	Kern	13	35.79		323	106	71	102	70	98	69	36	22	
Denair	Stanislaus	12	37.59	120 47	137	100	70	95	69	89	67	38	22	2974
Diamond Bar	Los Angeles	9	34		880	101	69	97	68	92	66	33	28	
Dinuba	Tulare	13	36.5		340	104	73	101	70	96	69	36	24	
Dixon	Solano	12	38.40	121 51	100	104	72	99	70	93	68	36	24	2826
Dobbins	Yuba	11	39.40	121 12	1640	104	70	101	68	96	67	31	24	
Donner Mem Stt Pk	Nevada/Placer	16	39.29	120 15	5937	85	56	82	56	77	54	40	-3	
Donner Summit	Placer	16	39.40	120 20	7239	80	53	77	53	72	50	40	-8	8290
Downey	Los Angeles	8	33.90	118 00	110	98	71	90	70	84	68	21	32	
Downieville RS	Sierra	16	39.59	120 48	2895	98	64	95	63	90	61	42	13	
Doyle	Lassen	16	40	120 06	4390	96	63	93	62	88	59	42	0	
Dry Canyon Res	Ventura	16	34.5	118 32	1455	105	71	100	69	96	68	32	24	
Duarte	Los Angeles	9	34.09		500	100	69	96	68	90	67	33	31	
Dublin	Alameda	12	37.70	121 30	200	99	69	93	67	86	65	35	24	
Dudleys	Mariposa	12	37.70	120 06	3000	97	65	94	64	90	62	44	10	4959
Duttons Landing		2	38.2	122 18	20	96	68	91	66	84	64	31	26	
Eagle Mtn	Riverside	14	33.79	115 27	973	113	72	110	71	105	69	24	32	1138
East Los Angeles	Los Angeles	9	34	118 15	250	99	69	92	68	86	67	21	38	
East Park Res	Colusa	11	39.40	122 31	1205	101	69	97	68	92	66	38	19	3455
Edwards AFB	Kern	14	34.90	117 52	2316	107	69	104	68	99	66	35	10	3123
El Cajon	San Diego	10	32.70	116 57	525	96	70	91	69	87	67	30	29	
El Capitan Dam	San Diego	14	32.90	116 49	600	105	71	98	70	93	68	35	29	1533
El Centro	Imperial	15	32.79	115 34	-30	115	74	111	73	107	73	34	26	1212
El Cerrito	Contra Costa	3	37.79		70	91	66	84	64	75	62	17	30	
El Mirage	San Bernardino	14	34.59		2910	105	69	101	68	97	66	31	9	
El Monte	Los Angeles	9	34.09		271	101	71	97	70	91	68	30	31	
El Rio	Ventura	6	34.29		50	95	69	88	68	82	66	20	30	
El Segundo	Los Angeles	6	33.90		105	91	69	84	68	79	66	14	37	
El Toro MCAS	Orange	8	33.70	117 44	380	96	69	89	69	82	68	26	34	1591
Electra PH	Amador	12	38.29	120 40	715	106	70	102	69	98	68	41	23	2858
Elk Valley	Del Norte	16	42	123 43	1705	96	65	90	63	84	61	39	16	5404
Elsinore	Riverside	10	33.70	117 20	1285	105	71	101	70	98	69	39	22	2128
Encinitas	San Diego	7	33		50	87	68	83	67	77	65	10	35	
Enterprise	Shasta	11	40.59		470	107	69	103	68	97	67	29	26	
Escondido	San Diego	10	33.09	117 05	660	97	69	90	68	84	67	29	26	2005
Eureka	Humboldt	1	40.79	124 10	43	75	61	69	59	65	58	11	30	4679
Fair Oaks	Sacamento	12	38.70	121 16	50	104	70	100	69	94	69	36	23	
Fairfax	Marin	2	38		110	96	68	90	66	83	63	34	26	
Fairfield FS	Solano	12	38.29	122 02	38	103	69	98	68	91	66	34	24	2686
Fairmont	Los Angeles	14	34.70	118 26	3060	100	67	96	66	92	65	22	22	3330
Fallbrook	San Diego	10	33.59	117 15	660	94	68	89	67	85	66	29	26	2077
Ferndale	Humboldt	1	40.5	124 18	1445	76	57	66	56	62	54	12	28	

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer .1% Dry Bulb	Summer 1% Wet Bulb	Summer .5% Dry Bulb	Summer .5% Wet Bulb	Summer 2% Dry Bulb	Summer 2% Wet Bulb	Summer Range	Winter Minimum	HDD
Fillmore	Verntura	9	34.40		435	100	70	94	69	87	67	30	28	
Five Points	Fresno	13	36.40	120 09	285	103	71	99	70	93	68	36	21	
Fleming Fish & Game	Lassen	16	40.40	120 19	4000	96	62	93	61	88	59	40	-3	
Florence-Graham	Los Angeles	8	34		175	98	69	90	68	84	67	19	35	
Florin	Sacramento	12	38.5		100	104	71	100	69	94	68	35	29	
Folsom Dam	Sacramento	12	38.70	121 10	350	104	70	101	69	95	67	36	25	
Fontana	San Bernardino	10	34.09	117 26	1090	105	70	101	69	97	67	33	30	1530
Forest Glen	Trinity	16	40.40	123 20	2340	96	65	92	64	88	62	42	12	
Fort Baker	Marin	3	37.79	122 28	15	87	66	81	65	73	65	12	33	3080
Fort Bidwell	Modoc	16	41.90	120 08	4498	93	60	90	59	85	57	38	-2	6381
Fort Bragg	Mendocino	1	39.5	123 49	80	75	60	67	59	62	58	15	29	4424
Fort Jones RS	Siskiyou	16	41.59	122 51	2725	98	64	93	63	88	61	44	5	5590
Fort MacArthur	San Diego	7	33.70	118 18	200	92	69	84	68	78	66	13	35	1819
Fort Ord	Monterey	3	36.70	121 46	134	86	65	77	63	70	60	18	24	3818
Fort Ross	Sonoma	1	38.5	123 15	116	79	63	74	62	65	59	19	30	4127
Foster City	San Mateo	3	37.5	122 14	20	92	67	84	65	76	63	22	29	
Fountain Valley	Orange	6	33.70		60	97	70	90	68	84	67	18	33	
Freedom	Santa Cruz	3	37		1495	89	67	85	64	79	62	22	27	
Fremont	Alameda	3	37.5	122 00	56	94	67	88	65	81	63	24	25	
Fresno AP	Fresno	13	36.79	119 43	328	104	73	101	71	97	68	34	24	2650
Friant Gov Camp	Fresno	13	37	119 43	410	106	72	103	70	100	68	40	23	2768
Fullerton	Orange	8	33.90		340	100	70	94	69	87	68	26	30	
Garden Grove	Orange	8	33.59		85	98	70	91	68	84	67	23	31	
Gardena	Los Angeles	8	33.90		40	92	69	85	68	80	66	18	32	
George AFB	San Bernardino	14	34.59	117 23	2875	105	67	102	65	98	62	31	19	2887
Georgetown RS	El Dorado	12	38.90	120 47	3001	98	64	95	63	90	61	31	18	
Giant Forest	Tulare	16	36.59	118 46	6412	84	56	81	55	77	53	26	5	
Gillespie Field	Solano	12	32.79		385	98	71	91	70	85	68	30	24	
Gilroy	Santa Clara	4	37	121 34	194	101	70	93	68	86	65	25	23	
Glen Avon	Riverside	10	34		827	105	70	101	69	95	67	35	28	
Glendale	Los Angeles	9	34.20		563	101	70	96	68	90	67	28	30	
Glendora	Los Angeles	9	34.09		822	102	69	98	68	92	67	35	30	
Glenville	Kern	16	35.70	118 44	3140	97	67	94	66	90	64	43	11	4423
Gold Rock Rch	Imperial	14	32.90		485	113	73	110	72	106	70	28	31	
Grant Grove	Tulare	16	36.70	118 58	6600	82	56	78	55	74	52	26	6	7044
Grass Valley	Nevada	11	39.20	121 04	2400	99	67	96	65	91	63	29	19	
Graton	Sonoma	2	38.40	122 52	200	95	68	91	67	82	64	34	22	3409
Grossmont	San Diego	7	32.70		530	96	69	89	68	84	66	23	31	
Grover City	San Luis	5	35.09		100	93	69	86	64	80	62	18	30	
Hacienda Hts	Los Angeles	9	34		300	100	69	96	68	90	67	28	31	
Haiwee	Inyo	16	36.09	117 57	3825	102	65	99	64	95	62	27	15	3700
Half Moon Bay	San Mateo	3	37.5	122 26	60	83	64	76	62	69	59	15	32	3843
Hamilton AFB	Marin	2	38.09	122 30	3	95	69	88	67	81	65	28	27	3311
Hanford	Kings	13	36.29	119 40	242	102	71	99	70	94	68	37	22	2736
Happy Camp RS	Siskiyou	16	41.79	123 22	1150	103	67	97	66	92	65	41	18	4263
Hat Creek PH 1	Shasta	16	40.90	121 33	3015	99	65	96	64	91	62	48	2	5689
Hawaiian Gardens	Los Angeles	8	33.79		75	97	70	91	69	84	67	23	32	
Hawthorne	Los Angeles	8	33.90		70	92	69	85	68	80	66	16	37	
Hayfield Pumps	Riverside	14	33.70	115 38	1370	112	71	108	70	104	68	31	24	1529

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer							Winter Minimum	HDD
						.1% Dry Bulb	1% Wet Bulb	.5% Dry Bulb	5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Range		
Hayward	Alameda	3	37.70	122 07	530	92	66	86	65	81	62	24	26	2909
Healdsburg	Sonoma	2	38.59	122 52	102	102	69	95	68	90	66	37	26	2572
Hemet	Riverside	10	33.70		1655	109	70	104	69	101	67	40	20	
Henshaw Dam	San Diego	10	33.20		2700	99	68	94	67	90	66	38	15	3708
Hermosa Beach	Los Angeles	6	33.90		16	92	69	84	68	78	66	12	38	
Hetch Hetchy	Tuolomne	16	38	119 47	3870	93	62	89	61	85	59	32	14	4816
Highland	San Bernardino	10	34.09		1315	106	70	102	69	97	68	36	26	
Hillcrest Center	Kern or Shasta	0	35.40		500	106	71	102	70	98	68	34	26	
Hillsborough	San Mateo	3	37.59	122 18	352	90	66	82	65	74	64	23	30	
Hilts	Siskiyou	16	42	122 38	2900	97	64	93	62	89	60	39	5	
Hollister	San Benito	4	36.90	121 25	280	96	68	89	67	81	65	30	21	2725
Hollywood	Los Angeles	9	34	118 23	384	96	70	89	69	83	67	20	36	
Hoopa	Humboldt	2	41	123 40	360	100	67	92	66	87	64	25	23	
Huntington Beach	Orange	6	33.70	117 48	40	91	69	83	67	76	66	14	34	
Huntington Lake	Fresno	16	37.20	119 13	7020	80	55	77	54	73	51	25	3	7632
Huntington Park	Los Angeles	8	34	118 00	175	98	70	90	69	84	67	20	38	
Idlewild	Del Norte	1	41.90	124 00	1250	103	68	96	66	92	65	40	18	
Idria	San Benito	4	36.40	120 40	2650	97	66	92	65	87	62	27	24	3128
Idyllwild	Riverside	16	33.70	116 43	5397	93	62	89	61	84	60	35	9	
Imperial AP	Imperial	15	32.79	115 34	-59	114	74	110	73	106	72	31	26	1060
Imperial Beach	San Diego	7	32.5	117 07	23	87	69	82	68	78	67	10	35	1839
Imperial CO	Imperial	16	32.90		-64	112	73	108	72	104	71	31	29	976
Independence	Inyo	16	36.79		3950	104	61	101	60	97	60	31	12	
Indio	Riverside	15	33.70	116 15	11	115	75	112	75	107	74	30	24	1059
Inglewood	Los Angeles	8	33.90	118 00	105	92	68	85	67	80	65	15	37	
Inyokern NAS	Kern	14	35.70	117 49	2440	110	71	106	68	102	66	37	15	2772
Iron Mtn	Shasta	11	34.09	115 08	922	116	75	112	74	108	73	26	29	1251
Irvine	Orange	8	33.70	118 00	50	96	69	88	68	82	67	27	33	
Isla Vista	Santa Barbara	6	34.5		40	90	69	83	67	77	65	20	33	
Jess Valley	Modoc	16	41.29		5300	92	59	89	58	84	56	35	-7	7045
John Wayne AP	Orange	7	33.59		115	98	70	91	68	84	67	26	33	1496
Julian Wynola	San Diego	14	33.09	116 48	3650	96	66	91	64	87	62	39	20	4049
Kentfield	Marin	2	38	122 33	120	97	66	91	65	84	63	35	27	3009
Kern River PH 1	Kings	13	35.5	118 47	970	106	72	103	71	99	69	26	30	1878
Kern River PH 3	Kern	16	35.79	118 34	2703	103	69	100	68	96	66	34	19	2891
Kettleman Stn	Kings	13	36.09	120 05	508	104	71	100	70	93	68	31	26	2180
King City	Monterey	4	36.20	121 08	320	94	67	90	65	85	64	36	20	2639
Klamath	Del Norte	1	41.5	124 05	25	79	62	71	60	66	58	18	26	4509
Knights Ferry	Stanislaus	12	37.79	120 34	315	103	70	99	68	94	67	37	19	
La Canada-Flintridge	Los Angeles	9	34.20	118 00	1365	99	69	95	68	88	66	30	32	
La Crescenta-Montrose	Los Angeles	9	34.20	118 00	1565	98	69	94	68	87	66	33	31	
La Habra	Orange	8	33.90	118 00	305	100	69	94	68	87	67	27	30	
La Mesa	San Diego	7	32.79	117 01	530	94	70	88	69	84	67	23	34	1567
La Mirada	Los Angeles	9	33.90	118 00	115	99	70	91	69	85	68	26	31	
La Palma	Orange	8	33.90	118 00	75	98	69	92	68	85	67	25	31	
La Puente	Los Angeles	9	34	118 00	320	101	71	97	70	91	69	28	31	
La Verne	Los Angeles	9	34.09	118 00	1235	101	69	97	68	91	67	34	29	
Lafayette	Contra Costa	12	37.90	122 08	535	100	69	94	67	87	66	32	24	
Laguna Beach	Orange	6	33.5	117 47	35	91	69	83	68	76	66	18	30	2222

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer .1% Dry Bulb	1% Wet Bulb	.5% Dry Bulb	.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Range	Winter Minimum	HDD
Lake Arrowhead	San Bernardino	16	34.2	117 11	5205	90	62	86	61	81	59	26	13	5310
Lake Spaulding	Nevada	16	39.29	120 38	5156	89	58	86	57	83	55	34	3	6447
Lakeport	Lake	2	39	122 55	1347	97	67	93	66	88	63	41	20	3728
Lakeshore	Fresno	16	40.90		1075	104	69	100	68	95	66	28	29	
Lakeside	San Diego	10	32.79	117 00	690	95	69	90	68	86	66	20	26	
Lakewood	Los Angeles	8	33.90	118 00	45	98	70	90	68	84	66	22	33	
Lamont	Kern	13	35.29	120 00	500	106	72	102	71	98	69	34	26	
Lancaster	Los Angeles	14	34.70	118 12	2340	106	68	102	67	98	66	35	12	
Larkspur	Marin	2	37.90	122 30	20	97	68	91	66	84	64	34	28	
Las Plumas	Butte	11	39.70		506	104	71	101	70	96	68	32	24	
Lava Beds	Siskiyou	16	41.70	121 31	4770	93	59	89	58	84	56	41	-1	
Lawndale	Los Angeles	8	33.90	118 00	66	92	69	85	68	80	66	16	37	
Le Grand	Merced	12	37.20	120 15	255	101	70	96	68	91	66	38	23	2696
Lemon Grove	San Diego	7	32.70	117 12	437	96	71	88	69	84	67	19	34	
Lemoncove	Tulare	13	36.40	119 02	513	105	72	102	70	98	68	38	25	2513
Lemoore NAS	Kings	13	36.29	119 57	228	104	72	101	71	97	69	37	19	2960
Lennox	Los Angeles	8	33.90	117 45	71	92	69	85	68	80	66	16	37	
Lindsay	Tulare	13	36.20	119 04	395	105	72	101	71	97	69	40	24	2634
Little Panoche	Fresno	13	36.79		677	100	68	94	67	86	66	33	23	
Livermore	Alameda	12	37.70	121 57	490	100	69	95	68	88	67	35	22	3012
Llano Shawnee	Los Angeles	14	34.5	117 45	3820	104	68	99	67	95	65	31	21	
Lodgepole	Lassen	16	36.59	118 43	6735	84	57	80	56	78	54	26	-4	
Lodi	San Joaquin	12	38.09	121 17	40	101	70	97	68	91	67	38	23	2859
Loma Linda	San Bernardino	10	34	117 30	1150	106	70	103	69	99	67	36	27	
Lomita	Los Angeles	6	33.79	119 00	56	95	69	87	68	81	66	18	33	
Lompoc	Santa Barbara	5	34.90	120 27	95	84	63	77	62	72	60	18	26	2888
Long Beach AP	Los Angeles	6	33.79	118 14	25	99	71	90	69	84	66	21	33	1606
Long Beach CO	Los Angeles	6	33.70	118 09	34	97	70	88	68	82	65	18	35	
Los Alamitos NAS	Orange	8	33.79	118 03	30	98	71	89	69	83	68	23	32	1740
Los Altos	Santa Clara	4	37.29	122 00	163	96	68	88	65	80	62	26	28	
Los Angeles AP	Los Angeles	6	33.90	118 24	97	91	67	84	67	79	66	14	37	1819
Los Angeles CO	Los Angeles	9	34	118 14	270	99	69	92	68	86	67	21	38	1245
Los Banos	Merced	12	37	120 52	120	100	70	96	68	88	67	42	22	2616
Los Banos Res	Merced	12	37	120 52	407	101	70	97	68	89	67	42	23	
Los Gatos	Santa Clara	4	37.20	121 58	365	98	69	90	67	82	66	32	26	2741
Lucerne Valley	San Bernardino	14	34.5	116 57	2957	105	67	101	66	98	64	38	12	
Lynwood	Los Angeles	8	33.90	118 00	88	98	70	90	69	83	67	21	32	
Madera	Madera	13	37	120 04	268	105	72	101	70	96	68	40	24	2673
Manhattan Beach	Los Angeles	6	33.90	118 00	120	91	69	84	68	79	66	12	38	
Manteca	San Joaquin	12	37.79	121 12	34	102	70	97	68	91	67	37	24	
Manzanita Lake	Shasta	16	40.5	121 34	5850	87	58	84	57	79	55	34	-3	7617
March AFB	Riverside	10	33.90	117 15	1511	103	70	99	68	94	65	34	23	2089
Maricopa	Kern	13	35.09	119 23	675	106	71	102	70	98	68	29	25	2302
Marina	Monterey	3	36.70		20	86	66	77	63	70	61	18	32	
Markley Cove		2	38.5	122 07	480	104	70	99	69	93	67	39	23	
Martinez FS	Contra Costa	12	38	122 08	40	99	67	94	66	88	65	36	28	
Marysville	Yuba	11	39.20	121 35	60	105	72	102	70	97	68	36	27	2552
Mather AFB	Sacramento	12	38.59	121 18	96	104	71	100	70	94	68	35	28	
Maywood	Los Angeles	8	34	118 00	170	97	70	91	69	85	67	21	34	

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer .1% Dry Bulb	Summer 1% Wet Bulb	Summer .5% Dry Bulb	Summer .5% Wet Bulb	Summer 2% Dry Bulb	Summer 2% Wet Bulb	Summer Range	Winter Minimum	HDD
McClellan AFB	Sacramento	12	38.70	121 24	86	105	71	102	70	96	68	35	23	2566
McCloud	Siskiyou	16	41.29	122 08	3300	96	63	93	62	87	60	42	5	5990
Mecca FS	Riverside	15	33.59	116 04	-180	115	75	111	75	107	74	30	24	1185
Menlo Park	San Mateo	3	37.40	122 20	65	94	67	86	65	78	63	25	27	
Merced AP	Merced	12	37.29	120 34	153	103	71	100	69	95	67	36	21	2653
Mill Creek	Tehama	16	35.09	117 01	2940	102	67	97	66	94	65	28	28	
Mill Valley	Marin	3	37.90	122 35	80	97	68	91	66	84	64	28	28	3400
Millbrae	San Mateo	3	37.59	122 21	10	90	66	82	63	74	61	24	30	
Milpitas	Santa Clara	4	37.40	121 54	15	94	68	87	65	79	63	27	27	
Mineral	Tehama	16	40.40	121 36	4911	90	60	87	59	82	57	38	2	7257
Miramir AFS	San Diego	7	32.90	117 08	477	97	69	91	68	86	67	22	32	1532
Mission Viejo	Orange	8	33.59	118 00	350	95	67	87	66	81	63	22	33	
Mitchell Caverns	San Berardino	14	34.90		4350	102	64	98	63	94	61	29	21	
Modesto	Stanislaus	12	37.59	121 00	91	102	73	99	70	95	68	36	25	2671
Moffett Field NAS	Santa Clara	4	37.40	122 03	39	89	68	84	66	78	64	23	30	2511
Mojave	Kern	14	35.09	118 11	2735	106	68	102	67	98	66	35	16	3012
Mono Lake	Mono	16	38	119 09	6450	91	58	88	57	84	55	32	4	6518
Monrovia	Los Angeles	9	34.20	118 18	562	100	69	96	68	90	67	30	33	
Montague	Siskiyou	16	41.79	122 28	2648	99	66	95	65	90	63	39	3	5474
Montclair	San Bernardino	10	34	117 00	1220	104	69	100	68	94	66	35	28	
Montebello	Los Angeles	9	34	118 06	205	98	69	93	68	86	67	24	33	
Monterey AP	Monterey	3	36.59	121 52	245	86	65	77	62	70	61	20	30	3556
Monterey CO	Monterey	3	36.59	121 52	345	87	65	78	62	71	61	20	32	3169
Monterey Park	Los Angeles	9	34	118 00	380	99	69	94	68	87	67	23	30	
Monticello Dam	Solano	2	38.5	122 07	505	105	71	100	70	94	68	39	26	
Moraga	Contra Costa	12	37.79	122 10	600	99	68	93	66	86	64	27	21	
Morgan Hill	Santa Clara	4	37.09	120 00	350	100	69	92	68	85	66	25	26	
Morro Bay FD	San Luis	5	35.40	120 51	115	88	65	82	64	76	62	14	31	
Mount Baldy Notch	San Bernardino	16	34.29	117 37	7735	80	58	76	57	71	54	32	4	
Mount Diablo	Contra Costa	12	37.90	121 55	2100	101	68	96	66	87	65	28	27	4600
Mount Hamilton	Santa Clara	4	37.29	121 39	4206	95	59	88	58	81	56	18	18	4724
Mount Hebron RS	Siskiyou	16	41.79	122 01	4250	92	60	88	59	82	57	42	-10	
Mount San Jacinto	Riverside	16	33.79	116 38	8417	82	56	77	55	73	53	35	-1	
Mount Shasta	Siskiyou	16	41.29	122 19	3535	93	62	89	61	84	59	34	8	5890
Mount Wilson	Los Angeles	16	34.20	118 04	5709	90	63	85	61	79	58	21	15	4296
Mountain Pass	San Bernardino	14	35.5	115 32	4730	100	65	96	64	92	63	29	11	
Mountain View	Santa Clara	4	37.5	121 54	95	93	67	85	64	77	62	25	28	
Nacimiento Dam	San Luis	4	35.79	120 53	770	100	68	94	66	88	64	35	22	
Napa State Hospital	Napa	2	37.29	122 16	60	94	67	91	67	86	66	29	26	2749
National City	San Diego	7	32.70	117 00	34	87	70	82	68	78	66	10	36	
Needles AP	San Bernardino	15	34.79	114 37	913	117	73	114	72	110	71	26	27	1391
Nevada City	Nevada	11	39.29	121 01	2600	97	66	94	64	88	63	41	14	4900
Newark	Alameda	3	37.5	122 02	10	94	68	89	67	82	65	24	29	
Newhall Soledad	Los Angeles	9	34.40	118 33	1243	104	70	100	68	95	67	42	27	
Newman	Stanislaus	12	37.29	121 03	90	104	71	99	69	93	67	38	22	
Newport Beach	Orange	6	33.59	117 53	10	87	68	80	66	72	65	12	34	1952
Norco	Riverside	10	33.90	117 00	700	103	70	99	69	94	67	34	27	
North Fork RS	Madera	16	37.20	119 30	2630	98	66	95	65	92	62	36	15	
North Highlands	Sacramento	12	38.59	121 25	45	104	71	100	69	94	67	35	23	2566

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer .1% Dry Bulb	1% Wet Bulb	.5% Dry Bulb	.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Range	Winter Minimum	HDD
North Hollywood	Los Angeles	9	34.20	118 23	619	102	70	97	69	91	67	31	28	
Norwalk	Los Angeles	8	33.9		97	99	69	90	68	84	67	26	31	
Novato	Marin	2	38.09	122 31	370	94	64	87	63	80	61	30	25	
Oakdale	Stanislaus	12	37.79	120 52	215	102	71	99	69	93	67	37	22	
Oakland AP	Alameda	3	37.70	122 12	6	91	66	84	64	77	62	20	32	2909
Oakland Museum	Alameda	3	37.79	122 10	30	96	68	89	66	82	63	20	31	
Oceanside	San Diego	7	33.20	117 24	10	84	69	80	67	74	65	10	33	
Oildale	Kern	13	35.5	119 00	450	106	71	102	70	98	68	34	26	
Ojai	Ventura	9	34.5	119 15	750	102	71	97	69	91	68	38	25	2145
Ontario AP	San Bernardino	10	34	117 00	934	105	70	101	69	95	66	34	26	1710
Orange	Orange	8	33.59	118 00	194	99	70	92	68	85	67	27	33	
Orange Cove	Fresno	13	36.59	119 18	431	104	71	100	69	97	68	38	25	2684
Orangevale	Sacramento	12	38.70	121 12	140	105	72	102	70	96	68	36	24	
Orick Prairie Creek	Humboldt	1	41.40	124 01	161	80	61	75	60	70	59	23	25	4816
Orinda	Contra Costa	12	37.90	122 10	550	99	68	93	66	86	64	32	21	
Orland	Glenn	11	39.79	122 12	254	105	71	102	70	97	68	36	22	2824
Orleans	Humboldt	2	41.29	123 32	403	104	70	97	68	91	66	42	21	3628
Oroville RS	Butte	11	39.5	121 33	300	106	71	104	70	98	69	37	25	
Otay-Castle Pk	San Diego	7	32.59	117 00	500	87	68	81	66	74	63	10	33	
Oxnard AFB	Ventura	6	34.20	119 11	49	94	69	86	68	79	67	21	30	2068
Pacific Grove	Monterey	3	36.70	122 00	114	87	66	78	63	71	61	19	31	
Pacifica	San Mateo	3	37.59	122 00	13	87	65	79	62	71	60	16	31	
Palm Desert	Riverside	15	33.70	116 30	200	116	74	112	73	108	72	34	26	
Palm Springs	Riverside	15	33.79	116 32	411	117	74	113	73	109	72	35	26	1109
Palmdale AP	Los Angeles	14	34.59	118 06	2517	107	67	103	67	98	64	33	12	2929
Palmdale CO	Los Angeles	14	34.59	118 06	2596	106	67	102	67	97	64	35	13	2908
Palo Alto	Santa Clara	4	37.5	122 08	25	93	66	85	64	77	62	25	26	2891
Palomar Obsy	San Diego	14	33.40	116 52	5545	90	62	85	61	80	59	22	16	4141
Palos Verdes	Los Angeles	6	33.79	119 00	216	92	69	84	68	78	66	14	38	
Paradise	Butte	11	39.79	121 36	1750	102	69	99	67	94	66	34	25	
Paramount	Los Angeles	8	33.90	117 00	70	98	70	90	69	84	67	22	32	
Parker Res	San Bernardino	15	34.29	114 10	738	115	74	112	73	108	72	26	32	1223
Pasadena	Los Angeles	9	34.20	118 09	864	99	69	94	68	88	67	30	32	1551
Paso Robles AP	San Luis	4	35.70	120 41	815	104	66	97	66	92	65	40	19	2973
Paso Robles CO	San Luis	4	35.59	120 41	700	102	65	95	65	90	65	44	16	2885
Pendleton MCB	San Diego	7	33.29	117 18	63	92	68	87	67	81	66	22	34	1532
Pendleton MCB Coast	San Diego	7	33.20	117 24	24	84	69	80	67	75	65	10	39	1782
Perris	Riverside	10	33.79	117 13	1470	105	70	101	69	97	68	39	22	
Petaluma FS 2	Sonoma	2	38.20	122 38	16	98	69	92	67	85	66	31	24	2959
Pico Rivera	Los Angeles	9	34	118 00	180	98	70	91	69	85	67	24	31	
Piedmont	Alameda	3	37.79	122 00	325	96	68	89	66	82	63	23	31	
Pinnacles NM	San Bernardino	14	36.5	121 11	1307	98	68	94	67	89	64	45	20	2956
Pinole	Contra Costa	3	38	122 18	10	91	66	87	65	82	64	25	30	
Pismo Beach	San Luis	5	35.09	120 37	80	92	66	85	64	80	62	16	30	2756
Pittsburg	Contra Costa	12	38	121 48	50	102	70	97	68	90	67	34	26	
Placentia	Orange	8	33.90	118 00	323	101	69	93	68	87	67	28	30	
Placerville	El Dorado	12	38.70	120 48	1890	101	67	98	66	93	65	42	20	4086
Placerville IFG	El Dorado	12	38.70	120 48	2755	100	66	97	65	92	64	42	23	
Platina	Shasta	11	40.40	122 53	2260	96	65	92	64	87	61	36	13	

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Pleasant Hill	Contra Costa	12	37.90	122 00	102	96	68	93	67	88	65	34	25	
Pleasanton	Alameda	12	37.59	121 47	350	97	68	94	67	89	65	35	24	
Point Arena	Mendocino	1	38.90	123 44	100	76	62	72	60	67	58	19	29	4747
Point Arguello	Santa Barbara	5	34.59	120 40	76	75	64	71	63	65	59	17	29	3826
Point Mugu	Ventura	6	34.09	119 07	14	88	68	81	67	75	66	15	33	2328
Point Piedras Blancas	San Luis	5	35.70	121 17	59	73	60	67	59	61	57	10	36	3841
Pomona Cal Poly	Los Angeles	9	34.09	117 49	740	102	70	98	69	93	67	36	27	1971
Port Chicago ND	Contra Costa	12	38	122 01	50	98	69	94	68	88	66	34	28	
Port Hueneme	Ventura	6	34.20	119 00	13	88	68	81	67	75	66	15	33	2334
Porterville	Tulare	13	36.09	119 01	393	106	71	102	70	97	69	36	25	2456
Portola	Plumas	16	39.79	120 28	4850	92	63	89	61	84	59	48	-9	7111
Posey 3 E	Tulare	13	35.79	119 00	4960	89	62	86	61	82	59	26	9	
Potter Valley PH	Mendocino	2	39.40	123 08	1015	101	68	96	67	89	65	40	20	3276
Poway Valley	San Diego	10	33	117 00	500	100	70	94	69	89	68	26	29	
Priest Valley	Monterey	4	36.20	120 42	2300	97	66	93	65	88	63	34	13	4144
Quincy	Plumas	16	39.90	120 56	3409	101	64	98	63	93	62	45	1	5763
Ramona Spaulding	San Diego	10	33.09	116 49	1480	103	70	97	69	92	68	40	22	
Rancho Cordova	Sacramento	12	38.59	121 18	190	104	72	100	69	94	68	35	26	
Rancho Palos Verdes	Los Angeles	6	33.70	118 10	216	92	69	84	68	78	66	14	38	
Randsburg	Kern	14	35.29	117 39	3570	105	67	102	66	97	65	30	19	2922
Red Bluff AP	Tehama	11	40.20	122 15	342	107	70	104	69	98	66	31	24	2688
Redding FS 4	Shasta	11	40.59	122 24	470	107	69	103	68	97	67	30	26	2544
Redlands	San Bernadino	10	34.09	117 11	1318	106	70	102	69	98	67	34	27	1993
Redondo Beach	Los Angeles	6	33.79	118 19	45	92	69	84	68	78	66	12	37	
Redwood City	San Mateo	3	37.5	122 14	31	90	67	86	66	81	64	28	28	2599
Reedley	Fresno	13	36.59	119 42	344	104	71	101	70	96	68	40	24	
Rialto	San Bernardino	10	34.09	117 00	1254	105	70	101	69	96	66	35	28	
Richardson Grove	Humbolt	2	40	123 47	500	96	67	92	66	87	64	28	25	
Richmond	Contra Costa	3	37.90	121 36	55	88	65	84	64	77	62	17	31	2684
Ridgecrest	Kern	14	35.59	117 48	2340	110	70	106	68	102	66	35	15	
Riverside Exp Sta	Riverside	10	34	117 23	986	106	71	102	69	97	67	36	29	
Riverside FS 3	Riverside	10	34	117 23	840	104	70	100	69	95	65	37	27	1818
Rocklin	Placer	11	38.79	121 14	239	108	72	104	70	99	69	39	20	3143
Rohnert Park	Sonoma	2	38.40	122 33	106	99	69	96	68	92	66	33	24	
Rolling Hills	Los Angeles	6	33.59	119 00	216	92	69	84	68	78	66	15	38	
Rosemead	Los Angeles	9	34	118 00	275	98	70	90	69	84	67	27	30	
Roseville	Placer	11	38.70	121 13	160	105	71	102	70	96	68	36	24	
Rossmoor	Orange	8	33.79		20	92	67	85	64	79	62	19	32	
Rowland Hts	Los Angeles	9	33.90	118 00	540	99	70	93	69	86	68	27	29	
Rubidoux	Riverside	10	34	117 00	792	106	71	102	70	97	68	36	27	
Sacramento AP	Sacramento	12	38.5	121 30	17	104	72	100	70	94	68	35	26	2843
Sacramento CO	Sacramento	12	38.59	121 30	84	104	71	100	70	94	68	32	30	
Saint Helena	Napa	2	38.5	122 28	225	102	70	98	69	93	67	40	22	2878
Saint Mary's College	Contra Costa	12	37.79	122 07	623	98	69	93	68	86	66	28	21	3543
Salinas 3 E	Monterey	3	36.70	121 36	85	86	66	83	65	79	62	20	26	
Salinas AP	Monterey	3	36.70	121 36	69	85	67	82	65	78	62	20	28	2959
Salt Springs PH	Amador/Calava	16	38.5	120 13	3700	95	62	92	61	87	59	27	19	3857
Salyer RS	Trinity	16	40.90	123 34	623	102	69	95	67	87	64	33	22	
San Anselmo	Marin	2	38	122 00	50	95	67	89	66	82	65	32	26	

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San Antonio Canyon	Los Angeles	16	34.20	117 40	2394	100	68	96	67	90	65	33	29	
San Antonio Mission	Monterey	4	36	117 40	1060	99	69	94	68	88	67	28	19	
San Bernardino	San Bernardino	10	34.1	117 19	1125	106	70	102	69	98	68	39	27	1777
San Bruno	San Mateo	3	37.7	122 25	20	86	66	80	64	73	62	23	30	3042
San Carlos	San Mateo	3	37.5		26	92	67	88	65	82	63	28	28	
San Clemente	Orange	6	33.40	118 35	208	91	68	85	67	80	66	12	31	
San Diego AP	San Diego	7	32.70	117 10	13	88	70	83	69	78	68	13	38	1507
San Dimas	Los Angeles	9	34		955	102	70	98	69	92	67	35	30	
San Fernando	Los Angeles	9	34.29	118 28	977	104	71	99	70	94	68	37	30	1800
San Francisco AP	San Francisco	3	37.59	122 23	8	89	66	83	64	74	61	20	31	3042
San Francisco CO	San Francisco	3	37.79	122 25	52	84	65	79	63	71	60	14	38	3080
San Gabriel FD	Los Angeles	9	34.09	118 06	450	99	70	94	69	88	68	30	30	1532
San Gregorio 2 SE	San Mateo	3	37.29		275	87	66	81	63	74	61	30	27	
San Jacinto	Riverside	10	33.79	116 58	1535	110	70	105	69	102	68	41	20	2376
San Jose	Santa Clara	4	37.40	121 56	67	94	68	86	66	78	64	26	29	2438
San Leandro	Alameda	3	37.70		45	89	67	83	64	76	62	22	28	
San Lorenzo	Alameda	3	37.70		45	89	67	83	64	76	62	23	28	
San Luis Dam	Merced	12	37.09		277	97	68	91	66	86	64	32	25	
San Luis Obispo	San Luis	5	35.29	120 43	320	94	63	87	63	81	62	26	30	2498
San Marino	Los Angeles	9	34.20		300	100	69	95	68	88	66	28	30	
San Mateo	San Mateo	3	37.5	122 18	21	92	67	84	65	76	63	24	31	2655
San Nicholas Island	Ventura	6	33.20	119 28	504	85	66	78	65	70	64	11	39	2454
San Pablo	Contra Costa	3	37.59		30	90	65	84	63	77	61	17	29	
San Pedro	Los Angeles	6	33.70	118 16	10	92	69	84	68	78	66	13	35	1819
San Rafael	Marin	2	38	122 33	40	96	67	90	65	83	63	29	30	2440
Sandberg	Los Angeles	16	34.79	118 44	4517	95	63	91	61	87	59	32	17	4427
Sanger	Fresno	13	36.70		364	105	72	101	70	96	68	37	24	
Santa Ana FS	Orange	8	33.79	117 50	115	98	70	91	68	84	67	26	33	1430
Santa Barbara AP	Santa Barbara	6	34.40	119 50	9	90	69	83	67	77	65	20	29	2487
Santa Barbara CO	Santa Barbara	6	34.40	119 41	5	91	69	84	67	78	65	22	33	1994
Santa Clara Univ	Santa Clara	4	37.40	121 56	88	90	67	87	65	82	63	30	29	2566
Santa Cruz	Santa Cruz	3	37	122 01	125	94	68	88	66	81	64	28	27	3136
Santa Fe Springs	Los Angeles	9	33.90		280	99	69	90	68	84	67	24	31	
Santa Maria AP	Santa Barbara	5	34.90	120 27	236	90	66	83	64	78	61	23	25	3053
Santa Monica	Los Angeles	6	34	118 30	15	85	67	78	66	72	64	15	39	1873
Santa Paula	Ventura	9	34.40		263	101	71	94	70	87	68	28	28	2030
Santa Rosa	Sonoma	2	38.5	122 49	167	99	69	96	68	92	66	35	24	2980
Santee	San Diego	10	32.79		400	96	69	91	68	87	67	20	25	
Saratoga	Santa Clara	4	37.29		500	96	67	88	66	80	65	31	27	
Sausalito	Sonoma	3	37.90		10	85	66	80	65	73	63	12	30	
Sawyer's Bar RS	Siskiyou	16	41.29		2169	100	66	95	65	88	62	38	14	4102
Scotia	Humboldt	1	40.5	124 22	139	78	61	74	60	69	58	19	28	3954
Seal Beach	Orange	6	33.79	118 05	21	94	69	86	68	80	65	15	35	1519
Seaside	Monterey	4	36.59		17	85	66	79	64	73	62	20	30	
Selma	Fresno	13	36.59		305	104	73	101	71	97	68	38	24	
Shafter	Kern	13	35.5	119 10	345	106	71	102	70	98	68	28	24	2185
Shasta Dam	Shasta	16	40.70		1076	105	69	101	68	95	67	27	29	2943
Shelter Cove	Humboldt	1	40	124 04	110	80	61	73	60	68	57	15	34	
Sierra City	Sierra	16	39.59	120 07	4230	96	62	93	61	89	59	43	12	

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Sierra Madre	Los Angeles	9	34.20		1153	102	69	96	68	90	67	27	32	
Sierraville RS	Sierra	16	39.59	120 22	4975	94	60	91	59	86	57	44	-10	6893
Signal Hill	Los Angeles	6	33.5		100	99	70	90	69	84	66	19	35	
Simi Valley	Ventura	9	34.40		500	98	70	93	68	87	66	30	28	
Sonoma	Sonoma	2	38.29		70	101	70	96	69	90	67	40	22	2998
Sonora RS	Tuolumne	12	38	120 23	1749	103	68	100	67	95	66	34	20	3537
South El Monte	Los Angeles	9	34		270	101	72	97	70	91	68	28	31	
South Entr Yosemite	Tuolumne	16	37.5	119 38	5120	92	61	88	60	84	59	36	8	5789
South Gate	Los Angeles	8	33.90		120	97	70	90	69	84	67	21	32	
South Lake Tahoe	El Dorado	16	38.90		6200	85	56	82	55	71	54	33	-2	
South Pasadena	Los Angeles	9	34		657	99	69	94	68	88	67	30	31	
South San Francisco	San Mateo	3	37.70		10	87	67	81	64	72	62	20	32	
South Whittier	Los Angeles	9	33.90		300	100	70	92	69	84	68	30	31	
Spring Valley	San Diego	10	32.70		300	94	69	86	68	82	66	30	34	
Squaw Valley	Placer	16	39.20		6235	88	57	85	56	80	54	40	-10	
Squirrel Inn	San Bernardino	14	34.20	117 14	5680	86	61	82	60	77	58	23	12	5175
Stanton	Orange	8	33.59		45	98	69	91	68	84	67	24	31	
Stockton AP	San Joaquin	12	37.90	121 15	22	103	71	98	69	93	67	35	24	2806
Stockton FS 4	San Joaquin	12	38	121 19	12	101	70	96	68	91	67	37	24	2846
Stony Gorge Res	Glenn	11	39.59	122 32	791	104	70	99	69	93	67	37	21	3149
Strawberry Valley	Tuolumne	16	39.59		3808	96	63	93	62	88	60	32	14	5120
Sunland	Los Angeles	9	34.29		1460	107	71	102	70	96	68	36	28	
Sunnyvale	Santa Clara	4	37.29	122 02	97	96	68	88	66	80	64	26	29	2511
Susanville AP	Lassen	16	40.40	120 34	4148	98	62	95	61	90	59	38	-1	6233
Tahoe City	Placer	16	39.20	120 08	6230	84	56	81	55	76	53	36	2	8085
Tahoe Valley AP	Placer	16	38.90		6254	85	56	82	55	77	53	38	-5	
Tehachapi	Kern	16	35.09		3975	97	66	93	65	89	64	33	13	4494
Tejon Rancho	Los Angeles	16	35	118 45	1425	107	71	103	70	99	68	27	24	2602
Temple City	Los Angeles	9	34.09		403	101	70	95	69	89	68	27	30	
Termo	Los Angeles	16	40.90		5300	95	60	92	59	87	57	37	-17	
Thermal AP	Riverside	15	33.59		-112	114	74	110	74	106	74	29	26	1154
Thousand Oaks	Ventura	9	34.20		810	98	69	93	68	88	67	30	27	
Three Rivers PH 1	Tulare	13	36.5		1140	105	70	102	69	98	67	38	24	2642
Tiburon	Marin	3	37.90		90	85	66	80	65	73	63	12	30	
Tiger Creek PH	Amador	12	38.5	120 29	2355	100	66	96	55	92	63	36	20	3795
Torrance	Los Angeles	6	33.79	118 20	110	93	69	86	68	80	66	18	32	1859
Tracy Carbona	San Joaquin	12	37.70		140	102	70	97	68	90	67	38	24	2704
Tracy Pumps	San Joaquin	12	37.79		61	104	71	99	69	92	68	39	23	
Travis AFB	Sonoma	12	38.29	121 56	72	103	71	98	69	91	66	35	24	2725
Trinity Dam	Trinity	16	40.79		2500	99	65	94	64	88	62	37	17	
Trona	San Bernardino	14	35.79	117 23	1695	113	72	109	70	105	68	35	18	2415
Truckee RS	Nevada	16	39.29	120 11	5995	90	58	87	57	82	55	40	-10	8230
Tujunga	Los Angeles	9	34.29		1820	103	70	99	69	94	67	36	20	
Tulare	Tulare	13	36.20		290	105	72	101	71	96	69	39	24	
Tulelake	Siskiyou	16	42		4035	92	60	88	59	83	57	41	-5	6854
Turlock	Stanislaus	12	37.5		100	104	72	100	70	95	68	40	24	
Turntable Creek	Plumas	0	40.79		1067	105	69	101	68	95	66	28	24	
Tustin Irvine Rch	Orange	8	33.70	117 47	118	99	71	92	69	85	68	27	28	1856

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Twentynine Palms	San Bernardino	0	34.09	116 03	1975	110	71	107	70	103	69	31	21	1973
Twin Lakes	Mono	16	38.70		7829	73	49	64	47	57	46	30	-7	9196
Twitchell Dam	San Luis	5	35		582	99	70	93	68	88	66	26	26	
UCLA	Los Angeles	9	34.09		430	93	69	86	68	80	66	20	39	1509
Ukiah	Mendocino	2	39.20	123 12	623	100	70	97	69	92	68	42	22	2958
Union City	Alameda	3	37.6		5	90	67	87	66	81	63	20	25	
Upland	San Bernardino	10	34.1		1605	102	69	98	68	92	66	31	29	2175
Upper Lake RS	Lake	2	39.20	122 57	1347	98	68	95	67	91	64	39	18	
Upper San Leandro	Alameda	3	37.79		394	93	67	87	66	80	63	22	28	
Vacaville	Solano	12	38.40		105	103	71	100	70	94	68	40	23	2788
Valinda	Los Angeles	9	34		340	102	70	98	69	92	68	28	31	
Vallejo	Solano	3	38.09		85	93	67	90	66	84	64	23	28	
Valyermo RS	Los Angeles	14	34.5		3600	100	67	96	66	91	65	41	12	3870
Vandenburg AFB	Santa Barbara	5	34.70	122 48	368	85	62	77	61	71	60	16	30	3451
Ventura	Ventura	6	34.29		341	89	68	82	67	76	66	15	29	
Victorville Pumps	San Bernardino	14	34.5		2858	105	67	101	65	97	62	39	14	3191
View Park	Los Angeles	6, 8	34		300	95	69	88	68	78	66	18	36	
Visalia	Tulare	13	36.29		325	103	71	100	70	96	69	38	25	2459
Vista	San Diego	7	33.20		510	96	69	90	68	85	67	16	30	
Volta PH	Merced	12	40.5		2220	101	66	98	65	93	63	33	21	
Walnut	Los Angeles	9	34		550	101	70	97	69	92	69	30	28	
Walnut Creek	Contra Costa	12	37.90		245	100	69	94	67	87	66	32	23	
Walnut Grove	Sacramento	12	38.20		23	102	70	98	69	92	68	37	24	
Warner Springs	San Diego	14	33.29		3180	100	67	95	66	91	65	40	15	3591
Wasco	Kern	13	35.59		333	105	71	101	70	97	68	36	23	2466
Watsonville	Santa Cruz	3	36.90		95	86	66	82	64	79	61	22	28	3418
Weaverville RS	Trinity	16	40.70		2050	100	67	95	66	89	63	46	10	4992
Weed FD	Siskiyou	16	41.40		3590	92	63	89	62	84	59	35	4	
West Carson	Los Angeles	9	33.79		100	92	69	87	68	81	66	18	32	
West Covina	Los Angeles	9	34		365	102	70	98	69	92	68	34	29	
West Hollywood	Los Angeles	9	34		290	95	70	89	69	82	67	20	38	
West Puente Valley			34		250	101	70	97	69	91	68	26	31	
Westminster	Orange	6	33.79		38	95	70	88	68	81	67	23	33	
Whiskeytown Res	Shasta	11	40.59		1295	105	69	101	68	96	67	31	25	
White Mtn 1	Mono	16	37.5		10150	73	49	69	47	65	45	37	-15	
White Mtn 2	Mono	16	37.59		12470	61	42	58	41	54	40	38	-20	
Whittier	Los Angeles	9	34		320	99	69	90	68	84	67	24	31	
Wildrose RS	Inyo	16	36.29		4100	100	64	97	63	93	61	33	13	
Williams	Colusa	11	39.20		85	104	71	100	70	94	68	36	24	
Willits	Mendocino	2	39.40	123 19	1350	95	66	89	65	82	62	38	18	
Willow Brook	Los Angeles	8	33.90		60	97	70	90	69	83	67	21	35	
Willow Creek	Humboldt	2	41	123 38	461	104	70	98	68	92	66	35	22	
Willows	Colusa	11	39.5		140	104	71	100	70	94	68	36	22	2836
Winters	Yolo	12	38.5		135	104	71	99	70	93	68	38	24	2593
Woodfords	Alpine	16	38.79		5671	92	59	89	58	84	56	32	0	6047
Woodland	Yolo	12	38.70		69	106	72	101	71	96	69	40	25	2708
Woodside	San Mateo	3	37.5		75	92	67	84	66	76	63	24	22	
Yorba Linda	Orange	8	33.90		350	102	70	94	69	88	68	31	30	1643
Yosemite Park Hq	Mariposa	16	37.70		3970	97	63	94	62	90	60	38	11	4785

City	County	Climate Zone	Latitude	Longitude (Degree Minute)	Elevation	Summer .1% Dry Bulb	Summer 1% Wet Bulb	Summer .5% Dry Bulb	Summer .5% Wet Bulb	Summer 2% Dry Bulb	Summer 2% Wet Bulb	Summer Range	Winter Minimum	HDD
Yreka	Siskiyou	16	41.70		2625	99	66	95	65	90	64	39	8	5395
Yuba City	Sutter	11	39.09		70	105	69	101	69	96	68	36	24	
Yucaipa	San Bernardino	10	34		2600	106	68	102	67	98	65	35	27	

D. Indoor Air Quality

EXECUTIVE SUMMARY

Public Resources Code (PRC), Section 25402, requires the California Energy Commission (Commission) to develop, implement, and periodically update energy efficiency standards for new buildings. AB 4655 (Tanner, 1988) added PRC Section 25402.8, requiring the Commission to examine the effects of energy efficiency standards on indoor air quality. Specifically, this legislation requires the Commission to: a) include in its deliberations, while developing building standards, the impact these standards could have on indoor air quality; and b) to complete, by December 31, 1991, a review of current energy efficiency standards to determine whether modifications are needed to reduce the potential for indoor air pollution. This report is a summary of that review.

History of Concern over Indoor Air Quality

Combined, the following factors have raised concern over the impact of indoor pollutants on human health:

The discovery that high concentrations of the carcinogenic (cancer-causing) radon gas may be found in more homes than previously assumed

Discovery of the possibility of high levels of carcinogenic asbestos fibers in some buildings with past applications of asbestos, a widely used insulating material

Growing number of non-specific health symptoms, which tend to occur when exposed to indoor pollutants

Employment trends toward working indoors

Building industry trends toward controlled indoor environments without occupant access to system controls or operable windows

Building industry practices during the energy crisis of restricting, if not eliminating, the use of outside air in heating and cooling systems

Building energy standards' incorporation of infiltration control requirements to reduce uncontrolled building air leakage

The growing number of volatile organic compounds found in typical homes and offices because of the use of manufactured products

Summary of Knowledge About Indoor Air Pollutants, Health Effects, Tight Building Syndrome and Building Related Illness

The main classes of pollutants (described along with related health effects) are:

- Biological contaminants
- Radon
- Combustion products
- Particulate matter
- Volatile organic compounds (VOCs) and semi-volatile organic compounds (SOCs)

"Tight building syndrome" cannot be linked to specific exposure to specific pollutants; a building-related illness (such as Legionnaire's Disease) can. Multiple chemical sensitivity (MCS), also known as Environmental Illness (EI), affects a significant subset of the population, leading to a heightened chemical sensitivity well beyond the normal sensitivity of the rest of the population.

Conceptual Approaches to Regulating Environmental Pollutants and Their Applicability to Indoor Environments

Environmental pollutants are currently regulated according to their potential to cause cancer or health effects other than cancer. This potential is assessed through the health risk assessment process. However, this risk assessment process is not useful for establishing energy-conserving ventilation requirements for buildings since there is no numerical correlation between ventilation rates and specific levels at risk.

The main factors that will affect the concentration of indoor air pollutants include:

- Effectiveness of any ventilation system in removing pollutants
- Care and maintenance of a building and its related systems
- Behavior of the building occupants
- Existence of entry pathways for pollutants
- Overall "air tightness" of the building
- Existence of significant indoor sources of pollution

Technological Approaches To Reducing Indoors Pollutants

The California Department of Health Services and Air Resources Board has identified source elimination as the most effective, economical and reliable method for reducing indoor concentrations of pollutants, with ventilation necessary for further reducing residual indoor pollutant levels. Ventilation is sometimes the most practical solution to immediate indoor air quality problems involving specific indoor pollutants from identifiable sources. In general, maintaining acceptable indoor air quality involves the approach of eliminating all known sources and providing adequate ventilation.

The concentration of a pollutant in a space is a function of the source strength and the dilution rate. The effects of the dilution rate on source strength is not easily quantifiable and is generally considered to be variable making it impossible to establish specific ventilation rates appropriate to all situations.

When formulating ventilation requirements for the purposes of reducing potential for pollutant accumulation, it is difficult to establish any one pollutant as an indicator of the absence of pollution-related health effects. Carbon dioxide levels have been identified from experience and limited studies as a roughly reliable indicator of acceptable indoor air quality. Total volatile organic compound (TVOC) concentration has been applied with some limited success as a general indicator of indoor pollutant levels. No other pollutants have been identified so far as capable of such an indicator role.

ASHRAE Standard 62-1989 bases its minimum ventilation rate on the same principle of minimizing levels of carbon dioxide as a way of maintaining indoor pollution within acceptable levels, as well as a general belief that higher levels of dilution reduce the potential for adverse health effects of indoor air pollution. The other components of the standard are based on committee consensus. Scientists have attempted to establish health-protective ventilation rates by using pollutants other than carbon dioxide as a surrogate for pollutant levels, but direct relationships between pollutant concentration and ventilation rates are difficult to establish because of the many factors that can affect the concentration of pollutants in any indoor environment.

The removal of pollutants from space can be accomplished in two ways: the pollutant-laden air can be exhausted from the space or treated to remove the pollutants of concern. At present, only limited confidence can be placed in the effectiveness of air treatment systems for protecting against health effects of indoor pollution due to the following factors: 1) air treatment is presently possible for only a small group of indoor pollutants; 2) the safe levels of many of these pollutants have not been established.

California's Energy Efficiency Standards

The Commission is required to develop cost-effective energy efficiency standards that include both mandatory and performance requirements. CEQA specifically requires the Commission to identify any potential negative environmental effects of compliance with these standards and to present alternatives, which will mitigate these effects.

The efficiency standards have unique features that conceivably could lead to increased indoor concentrations of pollutants. These include infiltration control requirements and mandatory insulation levels. There are no specific requirements for mechanical ventilation of residential buildings. The Commission concludes that these requirements do not present a major risk of increased indoor pollutants and that residential buildings are adequately ventilated because of the universal application of operable windows.

The standards for nonresidential buildings have incorporated minimum ventilation requirements since their effective date in 1978. Two revisions of the standards reflect the following facts:

Revision of ASHRAE Standard 62 in 1981 and 1989

Further research pointing to the need for at least 15-cfm per person to ensure that the concentrations of pollutants do not pose a risk of significant health effects

The inappropriateness of distinguishing between smoking and non-smoking buildings given the large number of hazardous indoor pollutants

Conclusion that demand controlled ventilation based on the levels of an acceptable indicator pollutant is the only reliable performance-based ventilation method

The 1992 nonresidential ventilation requirements can be met through natural or mechanical ventilation. The natural ventilation provisions limit this option to certain building geometrics. The mechanical ventilation requirements establish a minimum ventilation rate as the larger of a table value, in cfs per square foot, or 15 cfs per person. For office buildings, 0.15 cfs per square foot is required. This means that when an occupant density of 100 square feet per occupant is exceeded, the ventilation rate will be 15 cfs per person to reflect the increased need for carbon dioxide dilution.

The standards include provisions or requirements for the following:
Demand controlled ventilation
Supply of ventilation on a whole building basis
Pre-occupancy purge requirements
System control requirements
Requirements for supply of air to zonal heat pumps and fan coils
Completion and balancing requirements
The combined effects of higher ventilation rates and better efficiency requirements resulted in statewide energy savings. The Commission concluded the compliance with nonresidential standards would not lead to a significant increase in outdoor air pollution.

Commission's Strategy for Future Indoor Air Quality Research and Standards Development
Examination of the literature on indoor air quality issues shows substantial uncertainty about not only the best mechanisms for mitigating the problem in buildings, but also the essential elements of the problem being addressed in each situation. The Commission will continue examining these issues as part of the long-term plan to assess and update its building efficiency standards, as resources become available.
Based on the following key factors, the Commission is best equipped to establish ventilation rates for buildings covered by the energy efficiency standards.
The need for ventilation, and the extent of ventilation, should be determined from knowledge of the state's energy needs, as well as the magnitude of the indoor pollution problem.
Ventilation is not aimed at concentrations of single pollutants but at removing whole classes of pollutants.
The existing health risk assessment process is of limited usefulness in formulating specific numerical requirements for ventilation.
The Commission, since the first standards were established in 1978, has considered the impacts of its standards on indoor air quality in all of its revisions.

The Commission is the only agency assigned the task of balancing the impacts of its standards on both indoor and outdoor environments.
The Commission is able to assess the technological achievability, and cost effectiveness of its energy conservation standards.
The Commission's work to date includes:
Air leakage tests on pilot samples of homes built before and after the standards took effect.
Investigation of potential building elements that can affect indoor air quality and ventilation rates.
Participation of the Interagency Work Group on Indoor Air Quality, chaired by the Department of Health Services.
Revision of the minimum ventilation requirements for nonresidential buildings to reflect the latest understanding of the nature of pollution-related health effects.
Analysis of the potential impacts of compliance with the Commission's standards.
In complying with the statutory requirements of the Warren-Alquist Act, the Commission conducted an assessment of its building standards and indoor air quality during its 1992 revisions to the standards. The Commission concluded that the combined effects of occupant behavior, emission from pollutant sources and HVAC design necessitated substantial revisions to the nonresidential ventilation requirements. The Commission chose not to develop mechanical ventilation requirements for single family homes due to universal use of operable windows in homes.
Future work of the Commission, assuming availability of resources, will include:
Continued investigation and monitoring of both residential and nonresidential building air exchange rates.

Coordination with DHS, ARB, and federal agencies to develop a more reliable health risk assessment process for addressing indoor pollution problems.

Research in cooperation with ARB and DHS of the effectiveness of interim pollution reduction measures such as building commissioning and bake-outs.

Further research of ventilation effectiveness in terms of air mixing and the ability to remove the pollutants of most concern.

Continued standards refinement and public education efforts to help building occupants understand the factors affecting indoor air quality.

For detailed information, please request the following staff report from the Commission: "California's Energy Efficiency Standards and Indoor Air Quality"

E. Certified Computer Programs

Call the Energy Hotline for the latest update at **916/654-5106** or **1-800/772-3300** (in California only)

F. Publications Directory

Call the Energy Hotline for the latest update at **916/654-5106**
or
1-800/772-3300 (in California only)

G. Glossary

ACCA

is the Air-Conditioning Contractors of America.

ACCESSIBLE

is having access thereto, but which first may require removal or opening of access panels, doors, or similar obstructions.

ADDITION

is any change to a building that increases conditioned floor area and conditioned volume. See also, NEWLY CONDITIONED SPACE.

AIR-TO-AIR HEAT EXCHANGER

is a device which will reduce the heat losses or gains which occur when a building is mechanically ventilated, by transferring heat between the conditioned air being exhausted and the unconditioned air being supplied.

ALTERATION

is any change to a building's water heating system, space conditioning system, lighting system, or envelope that is not an addition.

ALTERNATIVE CALCULATION METHODS (ACMs)

are the Commission's Public Domain Computer Programs, one of the Commission's Simplified Calculation Methods, or any other calculation method approved by the Commission.

ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE)

is a measure of the percentage of heat from the combustion of gas or oil which is transferred to the space being heated during a year, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

ANNUNCIATED

is a visual signaling device that indicates the on, off, or other status of a load.

ANSI

is the American National Standards Institute.

APPLIANCE EFFICIENCY REGULATIONS

are the regulations in Title 20, Sections 1601 et. seq. of the California Code of Regulations.

APPROVED BY THE COMMISSION

means approval under Section 25402.1 of the Public Resources Code.

APPROVED CALCULATION METHOD
(See ALTERNATIVE CALCULATION METHODS).

ARI

is the Air-conditioning and Refrigeration Institute.

ASHRAE

is the American Society of Heating, Refrigerating, and Air-conditioning Engineers.

ASME

is the American Society of Mechanical Engineers.

ASTM

is the American Society for Testing and Materials.

ATRIUM

is an opening through two or more floor levels other than enclosed stairways, elevators, hoistways, escalators, plumbing, electrical, air-conditioning, or other equipment which is enclosed space and not defined as a mall.

AUDITORIUM

is the part of a public building where an audience sits in fixed seating, or a room, area, or building with fixed seats used for public meetings or gatherings not specifically for the viewing of dramatic performances.

AUTO REPAIR

is the portion of a building used to repair automotive equipment and/or vehicles, exchange parts, and may include work using an open flame or welding equipment.

AUTOMATIC

is capable of operating without human intervention.

AUTOMATIC TIME SWITCH CONTROL DEVICES

are devices capable of automatically turning loads off and on based on time schedules.

BANK/FINANCIAL INSTITUTION

is an area in a public establishment used for conducting financial transactions including the custody, loan, exchange, or issue of money, for the extension of credit, and for facilitating the transmission of funds.

BUILDING

is any structure or space for which a permit is sought.

BUILDING ENVELOPE

is the ensemble of exterior and demising partitions of a building that enclose conditioned space.

CAPTIVE-KEY OVERRIDE

is a type of lighting control in which the key that activates the override cannot be [removed] released when the lights are in the on position.

CERTIFYING ORGANIZATION

is an independent organization recognized by the Commission to certify manufactured devices for performance values in accordance with procedures adopted by the Commission.

CHANDELIERS

(see ORNAMENTAL CHANDELIERS).

CHAPTER 1

means the California Code of Regulations, Title 24, Part 2, Chapter 1.

CLASSROOM, LECTURE, OR TRAINING

is a room or area where an audience or class receives instruction.

CLIMATE CONTROL SYSTEM

(See SPACE CONDITIONING SYSTEM).

CLIMATE ZONES

are the 16 geographic areas of California for which the Commission has established typical weather data, prescriptive packages and energy budgets. Climate zone boundary descriptions are in the document "California Climate Zone Descriptions (July 1995, incorporated herein by reference)." Figure 1-A is an approximate map of the 16 climate zones.

COEFFICIENT OF PERFORMANCE (COP), COOLING,

is the ratio of the rate of net heat removal to the rate of total energy input, calculated under designated operating conditions and expressed in consistent units, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

COEFFICIENT OF PERFORMANCE (COP), HEATING,

is the ratio of the rate of net heat output to the rate of total energy input, calculated under designated operating conditions and expressed in consistent units, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

COMMERCIAL AND INDUSTRIAL STORAGE

is a room, area, or building used for storing items.

COMMISSION

is the California State Energy Resources Conservation and Development Commission.

COMPLETE BUILDING

is an entire building with one occupancy making up 90 percent of the conditioned floor area (see also ENTIRE BUILDING).

CONDITIONED FLOOR AREA (CFA)

is the floor area (in square feet) of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces of exterior walls enclosing the conditioned space.

CONDITIONED SPACE

is space in a building that is either directly conditioned, indirectly conditioned, or semi-conditioned.

CONDITIONED VOLUME

is the total volume (in cubic feet) of the conditioned space within a building.

CONVENTION, CONFERENCE, MULTIPURPOSE AND MEETING CENTERS

is an assembly room, area, or building that is used for meetings, conventions and multiple purposes including, but not limited to, dramatic performances, and that has neither fixed seating nor fixed staging.

COOLING EQUIPMENT

is equipment used to provide mechanical cooling for a room or rooms in a building.

CORRIDOR

is a passageway or route into which compartments or rooms open.

COVERED PRODUCT

is an appliance regulated by the efficiency standards established under the National Appliance Energy Conservation Act, 42 U.S.C. Section 6291 et seq.

CRAWL SPACE

is a space immediately under the first floor of a building adjacent to grade.

CTI

is the Cooling Tower Institute.

C-VALUE (also known as C-FACTOR)

is the time rate of heat flow through unit area of a body induced by a unit temperature difference between the body surfaces, in Btu (hr. x ft.^{2} x ^{o}F). It is not the same as K-value or K-factor.

DAYLIT AREA

is the space on the floor that is the larger of (a) plus (b), or (c);

(a) For areas daylit by vertical glazing, the daylit area has a length of 15 feet, or the distance on the floor, perpendicular to the glazing, to the nearest 60-inch or higher opaque partition, whichever is less; and a width of the window plus either 2 feet on each side, the distance to an opaque partition, or one-half the distance to the closest skylight or vertical glazing, whichever is least.

(b) For areas daylit by horizontal glazing, the daylit area is the footprint of the skylight plus, in each of the lateral and longitudinal dimensions of the skylight, the lesser of the floor-to-ceiling height, the distance to the nearest 60-inch or higher opaque partition, or one-half the horizontal distance to the edge of the closest skylight or vertical glazing.

(c) The daylit area calculated using a method approved by the Commission.

DECORATIVE GAS APPLIANCE

is a gas appliance that is designed or installed for visual effect only, cannot burn solid wood, and simulates a fire in a fireplace.

DEGREE DAY, HEATING

is a unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day, when the mean temperature is less than 65^{o}F, there exist as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65^{o}F. The number of degree days for specific geographical locations are those listed in the Residential Manual. For those localities not listed in the Residential Manual the number of degree days is as determined by the applicable enforcing agency.

DEMISING PARTITIONS

are barriers that separate conditioned space from enclosed unconditioned space.

DEMISING WALL

is a wall that is a demising partition.

DESIGN CONDITIONS

are the parameters and conditions used to determine the performance requirements of space conditioning systems. Design conditions for determining design heating and cooling loads are specified in Section 144(b) for nonresidential, high-rise residential, and hotel/motel buildings and in Section 150(h) for low-rise residential buildings.

DESIGN HEAT GAIN RATE

is the total calculated heat gain through the building envelope under design conditions.

DESIGN HEAT LOSS RATE

is the total calculated heat loss through the building envelope under design conditions.

DINING

is a room or rooms in a restaurant or hotel/motel (other than guest rooms) where meals that are served to the customers will be consumed.

DIRECTLY CONDITIONED SPACE

is an enclosed space that is provided with wood heating, is provided with mechanical heating that has a capacity exceeding 10 Btu/(hr ft^2), or is provided with mechanical cooling that has a capacity exceeding 5 Btu/(hr ft^2, unless the space conditioning system is designed and thermostatically controlled to maintain a process environment temperature less than 55 F or to maintain a process environment temperature greater than 90 F for the whole space that the system serves, or unless the space conditioning system is designed and controlled to be incapable of operating at temperatures above 55 F or incapable of operating at temperatures below 90 F at design conditions.

DISPLAY LIGHTING

is lighting confined to the area of a display that provides a higher level of illuminance than the level of surrounding ambient illuminance.

DISPLAY PERIMETER

is the length of an exterior wall in a B, F-1 or M occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk.

DISPLAY, PUBLIC AREA

are areas for the display of artwork, theme displays, and architectural surfaces in dining and other areas of public access, excluding restrooms and separate banquet rooms.

DISPLAY, SALES FEATURE

is an item or items that requires special highlighting to visually attract attention and that is visually set apart from the surrounding area.

DISPLAY, SALES FEATURE FLOOR

is a feature display in a retail store, wholesale store, or showroom that requires display lighting.

DISPLAY, SALES FEATURE WALL

are the wall display areas, in a retail or wholesale space, that are in the vertical plane of permanent walls or partitions, and that are open shelving feature displays or faces of internally illuminated transparent feature display cases within the Gross Sales Wall Area.

DUAL-GLAZED GREENHOUSE WINDOWS

are a type of dual-glazed fenestration product which adds conditioned volume but not conditioned floor area to a building.

EAST-FACING

is oriented to within 45 degrees of true east, including 45^{o}00’00" south of east (SE), but excluding 45^{o}00’00" north of east (NE).

ECONOMIZER, AIR

is a ducting arrangement and automatic control system that allows a cooling supply fan system to supply outside air to reduce or eliminate the need for mechanical cooling.

ECONOMIZER, WATER

is a system by which the supply air of a cooling system is cooled directly or indirectly by evaporation of water, or other appropriate fluid, in order to reduce or eliminate the need for mechanical cooling.

EFFECTIVE APERTURE (EA)

is (1) for windows, the visible light transmittance (VLT) times the window wall ratio; and (2) for skylights, the well index times the VLT times the skylight area times 0.85 divided by the gross exterior roof area.

EFFICACY

is the ratio of light from a lamp to the electrical power consumed (including ballast losses), expressed in lumens per watt.

ELECTRICAL/MECHANICAL ROOM

is a room in which the building's electrical switchbox or control panels, and/or HVAC controls or equipment is located.

ENCLOSED SPACE

is space that is substantially surrounded by solid surfaces.

ENERGY BUDGET

is the maximum amount of source energy that a proposed building, or portion of a building, can be designed to consume, calculated with the approved procedures specified in Part 6.

ENERGY EFFICIENCY RATIO (EER)

is the ratio of net cooling capacity (in Btu/hr) to total rate of electrical energy (in watts), of a cooling system under designated operating conditions, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

ENERGY FACTOR (EF)

is the ratio of energy output to energy consumption of a water heater, expressed in equivalent units, under designated operating conditions over a 24-hour use cycle, as determined using the applicable test method in the Appliance Efficiency Regulations.

ENERGY OBTAINED FROM DEPLETABLE SOURCES

is electricity purchased from a public utility, or any energy obtained from coal, oil, natural gas, or liquefied petroleum gases.

ENERGY OBTAINED FROM NONDEPLETABLE SOURCES

is energy that is not energy obtained from depletable sources.

ENFORCING AGENCY

is the city, county, or state agency responsible for issuing a building permit.

ENTIRE BUILDING

is the ensemble of all enclosed space in a building, including the space for which a permit is sought, plus all existing conditioned and unconditioned space within the structure.

ENVELOPE means BUILDING ENVELOPE.

EXERCISE CENTER/GYMNASIUM

is a room or building equipped for gymnastics, exercise equipment, or indoor athletic activities.

EXFILTRATION

is uncontrolled outward air leakage from inside a building, including leakage through cracks and interstices, around windows and doors, and through any other exterior partition or duct penetration.

EXHIBIT

is a room or area that is used for exhibitions that has neither fixed seating nor fixed staging.

EXPOSED THERMAL MASS

is mass that is directly exposed (uncovered) to the conditioned space of the building.

EXTERIOR DOOR

is a door through an exterior partition that is opaque or has a glazed area that is less than or equal to one-half of the door area. Doors with a glazed area of more than one-half of the door area are treated as a fenestration product.

EXTERIOR FLOOR/SOFFIT

is a horizontal exterior partition, or a horizontal demising partition, under conditioned space. For low-rise residential occupancies, exterior floors also include those on grade.

EXTERIOR PARTITION

is an opaque, translucent, or transparent solid barrier that separates conditioned space from ambient air or space that is not enclosed. For low-rise residential occupancies, exterior partitions also include barriers that separate conditioned space from unconditioned space, or the ground.

EXTERIOR ROOF/CEILING

is an exterior partition, or a demising partition, that has a slope less than 60 degrees from horizontal, that has conditioned space below, and that is not an exterior door or skylight.

EXTERIOR ROOF/CEILING AREA

is the area of the exterior surface of exterior roof/ceilings.

EXTERIOR WALL

is any wall or element of a wall, or any member or group of members, which defines the exterior boundaries or courts of a building and which has a slope of 60 degrees or greater with the horizontal plane. An exterior wall or partition is not an exterior floor/soffit, exterior door, exterior roof/ceiling, window, skylight, or demising wall.

EXTERIOR WALL AREA

is the area of the opaque exterior surface of exterior walls.

FENESTRATION PRODUCT

is any transparent or translucent material plus any sash, frame, mullions, and dividers, in the envelope of a building, including, but not limited to: windows, sliding glass doors, french doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one-half of the door area.

FIELD-FABRICATED FENESTRATION PRODUCT OR EXTERIOR DOOR

is a fenestration product or exterior door whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked down products, sunspace kits and curtainwalls).

FIREPLACE

is a hearth and fire chamber or similar prepared place in which a solid fuel fire may be burned, as defined in UBC Section 3702 and as further clarified in UBC Section 3707; these include but are not limited to factory-built fireplaces, masonry fireplaces, and masonry heaters.

FLOOR/SOFFIT TYPE

is a floor/soffit assembly having a specific heat capacity, framing type, and U-Factor.

FRAMED PARTITION or ASSEMBLY

is a partition or assembly constructed using separate structural members spaced not more than 32 inches on center.

GAS HEATING SYSTEM

is a natural gas or liquefied petroleum gas heating system.

GAS LOG

is a self-contained, free-standing, open-flame, gas-burning appliance consisting of a metal frame or base supporting simulated logs, and designed for installation only in a vented fireplace.

GENERAL COMMERCIAL AND INDUSTRIAL WORK

is a room, area, or building in which an art, craft, assembly or manufacturing operation is performed.

GENERAL LIGHTING

is lighting designed to provide a substantially uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect. When designed for lower-than-task illuminance used in conjunction with other specific task lighting systems, it is also called "ambient" lighting.

GLAZING

(See FENESTRATION PRODUCT).

Center of Glass U-Factor:

The U-factor of an IG unit (or single glazing) other than within two and a half inches of dividers or edge of glass.

Dividers:

Muntins; wood, aluminum or vinyl glazing dividers; may be true divided lights, between the panes, or applied to the exterior or interior of the glazing.

Edge of Glass:

The area of glazing within two and a half inches of the spacer.

Frame Types:

- **Thermal Break**

  Metal frames that are not solid metal from the inside to the outside, but are separated in the middle by a material, usually vinyl, with a lower conductivity.

- **Vinyl**

  A PVC compound used for frame and mountain elements, with a lower conductivity than metal and a similar conductivity to wood.

- **Gap Width**

  The distance between glazings in multi-glazed systems. This is typically measured from inside surface to inside surface, though some manufacturers may report "overall" IG width which is measured from outside surface to outside surface.

- **Gas In fills**

  Air, argon, krypton, CO_2, SF_6, or a mixture of these gasses. Gas in fills are between the panes of dual or triple glazing.

- **Grilles**

  see Dividers

- **IG Unit**

Insulating glass unit; includes the glazings, spacer(s), films (if any), gas in fills, and edge caulking.

- **Low-e Coatings**

  Low emissivity metallic coatings

- **Soft Coat**

  "Sputter" applied coating; sprayed on at a high temperature; usually susceptible to degradation (oxidation) from contact through handling or storing; generally provides a lower emissivity (and better thermal performance) than hard coatings.

- **Hard Coat**

  Low emissivity metallic coatings applied pyrolytically (at or near the melting point of the glass so that it bonds with the surface layer of glass); hard coatings are not subject to oxidation and scratching as the soft coats are. The first generation of hard coatings performed only about one fourth as well as the soft coats (emissivities around 0.40 as compared to emissivities around 0.10), but new hard coat technologies provide performance very close to that of the soft coatings.

  > Note: Low-e coatings will lower the shading coefficient in addition to reducing heat loss, but there is no direct relationship between emissivity and shading coefficient (e.g., a dual glazed unit with an emissivity of 0.22 may have a shading coefficient of 0.86 - nearly identical to clear dual glazing - or it may have a shading coefficient of 0.40).

- **Mullion**

  Vertical framing members separating adjoining window or door sections.

- **Muntins**

  see Dividers

- **NFRC**

  National Fenestration Rating Council. This is a national organization of fenestration product manufacturers, glazing manufacturers, manufacturers of related materials, utilities, state energy offices, laboratories, home builders, specifiers (architects), and public interest groups.

Spacers:

- **Aluminum**

  Metal channel that is used either against the glass (sealed along the outside edge of the insulated glass unit), or separated from the glass by one or more beads of caulk.

- **Squiggle**

  A flexible material, usually butyl, formed around a thin corrugated aluminum strip

- **"Insulating"**

Non-metallic, fairly non-conductive materials, usually of rubber compounds

- **Others**

  Wood, fiberglass, composites

Suspended Films:

Low-e coated plastic films stretched between the elements of the spacers between panes of glazing; acts as a reflector to slow the loss of heat from the interior to the exterior.

GOVERNMENTAL AGENCY

is any public agency or subdivision thereof, including, but not limited to, any agency of the state, a county, a city, a district, an association of governments, or a joint power agency.

GROCERY STORE

is a room, area, or building that has as its primary purpose the sale of foodstuffs requiring additional preparation prior to consumption.

GROSS EXTERIOR ROOF AREA

is the sum of the skylight area and the exterior roof/ceiling area.

GROSS EXTERIOR WALL AREA

is the sum of the window area, door area, and exterior wall area.

GROSS SALES FLOOR AREA

is the total area (in square feet) of retail store floor space that is (1) used for the display and sale of merchandise; or (2) associated with that function, including, but not limited to, sales transactions areas, fitting rooms, and circulation areas and entry areas within the space used for display and sale.

GROSS SALES WALL AREA

is the area (in square feet) of the inside of exterior walls and permanent full height interior partitions within the gross sales floor area of a retail store that is used for the presentation of merchandise for sale, less the area of openings, doors, windows, baseboards, wainscots, mechanical or structural elements, and other obstructions preventing the use of the area for the presentation of merchandise.

HABITABLE STORY

is a story that contains space in which humans may work or live in reasonable comfort, and that has at least 50 percent of its volume above grade.

HEAT CAPACITY (HC)

of an assembly is the amount of heat necessary to raise the temperature of all the components of a unit area in the assembly one degree F. It is calculated as the sum of the average thickness times the density times the specific heat for each component, and is expressed in Btu per square foot per degree F.

HEAT PUMP

is a device that is capable of heating by refrigeration, and that may include a capability for cooling.

HEATING EQUIPMENT

is equipment used to provide mechanical heating for a room or rooms in a building.

HEATING SEASONAL PERFORMANCE FACTOR (HSPF)

is the total heating output of a heat pump (in British thermal units) during its normal use period for heating divided by the total electrical energy input (in watt-hours) during the same period, as determined using the applicable test method in the Appliance Efficiency Regulations.

HI

is the Hydronics Institute.

HIGH BAY

is a space with luminaires 25 feet or more above the floor.

HIGH-RISE RESIDENTIAL BUILDING

is a building, other than a hotel/motel, of occupancy group R-1 with four or more habitable stories.

HORIZONTAL GLAZING

(See SKYLIGHT).

HOTEL FUNCTION AREA

is a hotel room or area such as a hotel ballroom, meeting room, exhibit hall, or conference room, together with prefunction areas and other spaces ancillary to its function.

HOTEL LOBBY

is the contiguous spaces in a hotel/motel between the main entrance and the front desk, including waiting and seating areas, and other spaces encompassing the activities normal to a hotel lobby function.

HOTEL/MOTEL

is a building or buildings incorporating six or more guest rooms or a lobby serving six or more guest rooms, where the guest rooms are intended or designed to be used, or which are used, rented, or hired out to be occupied, or which are occupied for sleeping purposes by guests, and all conditioned spaces within the same building envelope. Hotel/motel also includes all conditioned spaces which are (1) on the same property as the hotel/motel, (2) served by the same central HVAC system as the hotel/motel, and (3) integrally related to the functioning of the hotel/motel as such, including, but not limited to, exhibition facilities, meeting and conference facilities, food service facilities, lobbies, and laundries.

HVAC SYSTEM

(see SPACE CONDITIONING SYSTEM).

INDIRECTLY CONDITIONED SPACE

is enclosed space including, but not limited to, unconditioned volume in atria, that (1) is not directly conditioned space; and (2) either (a) has an area-weighted heat transfer coefficient to directly conditioned space exceeding that to the outdoors or to unconditioned space, or (b) is a space through which air from directly conditioned spaces is transferred at a rate exceeding 3 air changes per hour.

INFILTRATION

is uncontrolled inward air leakage from outside a building, or unconditioned space, including leakage through cracks and interstices, around windows and doors, and through any other exterior or demising partition or pipe or duct penetration.

INTEGRATED PART LOAD VALUE (IPLV)

is a single number figure of merit based on part load EER or COP expressing part load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

ISOLATION DEVICE

is a device that prevents the conditioning of a zone or group of zones in a building while other zones of the building are being conditioned.

KITCHEN/FOOD PREPARATION

is a room or area with cooking facilities and/or an area where food is prepared.

LAUNDRY

is a place where laundering activities occur.

LIBRARY

is a repository for literary materials, such as books, periodicals, newspapers, pamphlets and prints, kept for reading or reference.

LOCKER/DRESSING ROOM

is a room or area for changing clothing, sometimes equipped with lockers.

LOUNGE/RECREATION

is a room used for leisure activities which may be associated with a restaurant or bar.

LOW BAY

is a space with luminaires less than 25 feet above the floor.

LOW-RISE RESIDENTIAL BUILDING

is a building, other than a hotel/motel, that is of occupancy group R-1 and is three stories or less, or that is of occupancy group R-3.

LPG

is Liquefied Petroleum Gas.

LUMEN MAINTENANCE DEVICE

is a device capable of automatically adjusting the light output of a lighting system throughout a continuous range to provide a preset level of illumination.

LUMINAIRE

is a complete lighting unit consisting of a lamp and the parts designed to distribute the light, to position and protect the lamp, and to connect the lamp to the power supply; commonly referred to as “lighting fixtures” or “instruments.”

MAIN ENTRY LOBBY/RECEPTION/WAITING

is the lobby of a building that is directly located by the main entrance of the building and includes the reception area, sitting areas, and public areas.

MALLS, ARCADES AND ATRIA

is a public passageway or concourse that provides access to rows of stores or shops.

MANUAL

is capable of being operated by personal intervention.

MANUFACTURED DEVICE

is any heating, cooling, ventilation, lighting, water heating, refrigeration, cooking, plumbing fitting, insulation, door, fenestration product, or any other appliance, device, equipment, or system subject to Sections 110 through 119 of Part 6.

MANUFACTURED FENESTRATION PRODUCT

is a fenestration product typically assembled before delivery to a job site. Knocked down or partially assembled products sold as a fenestration product must be considered a manufactured fenestration product and meet the rating and labeling requirements for manufactured fenestration products.

MECHANICAL COOLING

is lowering the temperature within a space using refrigerant compressors or absorbers, desiccant dehumidifiers, or other systems that require energy from depletable sources to directly condition the space. In nonresidential, high-rise residential, and hotel/motel buildings cooling of a space by direct or indirect evaporation of water alone is not considered mechanical cooling.

MECHANICAL HEATING

is raising the temperature within a space using electric resistance heaters, fossil fuel burners, heat pumps, or other systems that require energy from depletable sources to directly condition the space.

MEDICAL AND CLINICAL CARE

is a room, area, or building that does not provide overnight patient care and that is used to promote the condition of being sound in body or mind through medical, dental, or psychological examination and treatment, including, but not limited to, laboratories and treatment facilities.

MODELING ASSUMPTIONS

are the conditions (such as weather conditions, thermostat settings and schedules, internal gain schedules, etc.) that are used for calculating a building's annual energy consumption and that are in the Alternative Calculation Methods Manuals.

MOVABLE SHADING DEVICE

(See OPERABLE SHADING DEVICE).

MULTI-SCENE DIMMING SYSTEM

is a lighting control device that has the capability of setting light levels throughout a continuous range, and that has pre-established settings within the range.

MUSEUM

is a space in which works of artistic, historical, or scientific value are cared for and exhibited.

NEWLY CONDITIONED SPACE

is any space being converted from unconditioned to directly conditioned or indirectly conditioned space, or any space being converted from semi-conditioned to directly conditioned or indirectly conditioned space. Newly conditioned space must comply with the requirements for an addition. See Section 149 for nonresidential occupancies and Section 152 for residential occupancies.

NONRESIDENTIAL BUILDING

is any building which is of occupancy group A, B, E, F, H, M or S.

NOTE: Requirements for high-rise residential buildings and hotels/motels are included in the nonresidential sections of Part 6.

NONRESIDENTIAL MANUAL

is the manual developed by the Commission, under Section 25402.1(c) of the Public Resources Code, to aid designers, builders and contractors in meeting the energy efficiency requirements for nonresidential, high-rise residential, and hotel/motel buildings.

NORTH-FACING

is oriented to within 45 degrees of true north, including $45^{o}00'00"$ east of north (NE), but excluding $45^{o}00'00'$ west of north (NW).

OCCUPANCY SENSOR, LIGHTING

is a device that automatically turns lights off soon after an area is vacated.

OCCUPANCY TYPE

is one of the following:

- **Auditorium:**

  The part of a public building where an audience sits in fixed seating, or a room, area, or building with fixed seats used for public meetings or gatherings not specifically for the viewing of dramatic performances.

  Auto Repair:

  The portion of a building used to repair automotive equipment and/or vehicles, exchange parts, and may include work using an open flame or welding equipment.

- **Bank/Financial Institution:**

  A public establishment for conducting financial transactions including the custody, loan, exchange, or issue of money, for the extension of credit, and for facilitating the transmission of funds.

  Classroom, Lecture, Or Training:

  A room or area where an audience or class receives instruction.

- **Commercial and Industrial Storage:**

  A room, area, or building used for storing items.

- **Convention, Conference, or Meeting Center:**

  An assembly room, area, or building that is used for meetings, conventions and multiple purposes including, but not limited to, dramatic performances, and that has neither fixed seating nor fixed staging.

- **Corridor:**

  A passageway or route into which compartments or rooms open.

- **Dining:**

  A room or rooms in a restaurant or hotel/motel (other than guest rooms) where meals that are served to the customers will be consumed.

- **Exhibit:**

  A room or area that is used for exhibitions that has neither fixed seating nor fixed staging.

- **General Commercial and Industrial Work:**

  A room, area, or building in which art, craft, assembly or manufacturing operation is performed.

- **Grocery Store**

  A room, area, or building that has as its primary purpose the sale of foodstuffs requiring additional preparation prior to consumption.

- **Hotel Function Area:**

  A hotel room or area such as a hotel ballroom, meeting room, exhibit hall, or conference room, together with prefunction areas and other spaces ancillary to its function.

- **Hotel Lobby:**

  The contiguous spaces in a hotel/motel between the main entrance and the front desk, including waiting and seating areas, and other spaces encompassing the activities normal to a hotel lobby function.

- **Kitchen:**

  A room or area with cooking facilities in it.

- **Main Entry Lobby:**

  The lobby of a building that is directly located by the main entrance of the building and includes the reception area, sitting areas, and public areas.

- **Malls and Arcades:**

  A public passageway or concourse that provides access to rows of stores or shops.

- **Medical and Clinical Care**:

  A room, area, or building that does not provide overnight patient care and that is used to promote the condition of being sound in body or mind through medical, dental, or psychological examination and treatment, including, but not limited to, laboratories and treatment facilities.

- **Office**:

  A room, area, or building of UBC group B occupancy other than restaurants.

- **Precision Commercial or Industrial Work:**

  A room, area, or building in which an art, craft, assembly or manufacturing operation is performed involving visual tasks of small size or fine detail such as electronic assembly, fine working, metal lathe operations, fine hand painting and finishing, egg processing operations, or tasks of similar visual difficulty.

- **Reception/Waiting Area:**

  An area where customers or clients are greeted prior to conducting business.

- **Religious Worship:**

  A room, area, or building for worship.

- **Restaurant:**

A room, area, or building that is a food establishment as defined in Section 27520 of the Health and Safety Code.

- **Restroom:**

  A room or suite of rooms providing personal facilities such as toilets and washbasins.

- **Retail and Sales:**

  A room, area, or building in which the primary activity is the sale of merchandise.

- **School:**

  A building or group of buildings that is predominately classrooms and that is used by an organization that provides instruction to students.

- **Stairs, Active/Inactive:**

  A series of steps providing passage from one level of a building to another.

  Support Area:

  A room or area used as a passageway, utility room, storage space, or other type of space associated with or secondary to the function of an occupancy that is listed in these regulations.

- **Support Space:**

  A room or area used as a passageway, utility room, storage space, or other type of space associated with or ancillary to the function of an occupancy that is listed in these regulations.

- **Theater, Motion Picture:**

  An assembly room, hall, or building with tiers of rising seats or steps for the showing of motion pictures.

- **Theater, Performance**:

  An assembly room, hall, or building with tiers of rising seats or steps for the viewing of dramatic performances, lectures, musical events and similar live performances.

- **Vocational Room:**

  A room used to provide training in a special skill to be pursued as a trade.

- **Wholesale Showroom:**

  A room where samples of merchandise are displayed.

OFFICE

is a room, area, or building of UBC group B occupancy other than restaurants.

OPERABLE SHADING DEVICE

is a device at the interior or exterior of a building or integral with a fenestration product, which is capable of being operated, either manually or automatically, to adjust the amount of solar radiation admitted to the interior of the building.

OPTIMAL OVERHANG

is an overhang that completely shades the glazing at solar noon on August 21 and substantially exposes the glass at solar noon on December 21.

ORNAMENTAL CHANDELIERS

are ceiling-mounted, close-to-ceiling, or suspended decorative luminaires that use glass, crystal, ornamental metals, or other decorative material and that typically are used in hotel/motels, restaurants, or churches as a significant element in the interior architecture.

OUTDOOR AIR (Outside air)

is air taken from outdoors and not previously circulated in the building.

OVERALL HEAT GAIN

is the value obtained in Section 143(b)2 for determining compliance with the component envelope approach.

OVERALL HEAT LOSS

is the value obtained in Section 143(b)1 for determining compliance with the component envelope approach.

POOR QUALITY LIGHTING TASKS

are visual tasks that require illuminance category _E_ or greater, because of the choice of a writing or printing method that produces characters that are of small size or lower contrast than good quality alternatives that are regularly used in offices.

PRECISION COMMERCIAL OR INDUSTRIAL WORK

is a room, area, or building in which an art, craft, assembly or manufacturing operation is performed involving visual tasks of small size or fine detail such as electronic assembly, fine woodworking, metal lathe operation, fine hand painting and finishing, egg processing operations, or tasks of similar visual difficulty.

PRIVATE OFFICE or WORK AREA

is an office bounded by 30-inch or higher partitions and is no more than 200 square feet.

PROCESS

is an activity or treatment that is not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

PROCESS LOAD

is a load resulting from a process.

PUBLIC AREAS

are spaces generally open to the public at large, customers, congregation members, or similar spaces, where occupants need to be prevented from controlling lights for safety, security, or business reasons.

PUBLIC FACILITY RESTROOM

is a restroom designed for use by the public.

RAISED FLOOR

is a floor (partition) over a crawl space, or an unconditioned space, or ambient air.

READILY ACCESSIBLE

is capable of being reached quickly for operation, repair, or inspection, without requiring climbing or removing obstacles, or resorting to access equipment.

RECEPTION/WAITING AREA

is an area where customers or clients are greeted prior to conducting business.

RECOOL

is the cooling of air that has been previously heated by space conditioning equipment or systems serving the same building.

RECOVERED ENERGY

is energy used in a building that (1) is mechanically recovered from space conditioning, service water heating, lighting, or process equipment after the energy has performed its original function; (2) provides space conditioning, service water heating, or lighting; and (3) would otherwise be wasted.

REDUCED FLICKER OPERATION

is the operation of a light, in which the light has a visual flicker less than 30% for frequency and modulation.

REHEAT

is the heating of air that has been previously cooled by cooling equipment or systems or an economizer.

RELATIVE SOLAR HEAT GAIN

is the ratio of solar heat gain through a fenestration product (corrected for external shading) to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

RELIGIOUS WORSHIP

is a room, area, or building for worship.

REPAIR

is the reconstruction or renewal of any part of an existing building for the purpose of its maintenance.

RESIDENTIAL BUILDING

(See HIGH-RISE RESIDENTIAL BUILDING and LOW-RISE RESIDENTIAL BUILDING).

RESIDENTIAL MANUAL

is the manual developed by the Commission, under Section 25402.1(c) of the Public Resources Code, to aid designers, builders, and contractors in meeting energy efficiency standards for low-rise residential buildings.

RESTAURANT

is a room, area, or building that is a food establishment as defined in Section 27520 of the Health and Safety Code.

RESTROOM

is a room or suite of rooms providing personal facilities such as toilets and washbasins.

RETAIL AND SALES

is a room, area, or building in which the primary activity is the sale of merchandise.

ROOF/CEILING TYPE

is a roof/ceiling assembly having a specific framing type and U-factor.

ROOM CAVITY RATIO (RCR) is:

(a) for rectangular rooms $\frac{5H\ (L + W)}{LW}$

;or

(b) for irregular shaped rooms $\frac{2.5\ H \times P}{A}$

Where:

L = Length of room

W = Width of room

H = Vertical distance from the work plane to the center line of the lighting fixture

P = Perimeter of room

A = Area of room

RUNOUT

is piping that is no more than 12 feet long and that is connected to a fixture or an individual terminal unit.

SCHOOL

is a building or group of buildings that is predominately classrooms and that is used by an organization that provides instruction to students.

SCONCE

is a wall mounted decorative light fixture.

SEASONAL ENERGY EFFICIENCY RATIO (SEER)

means the total cooling output of a central air conditioner in British thermal units during its normal usage period for cooling divided by the total electrical energy input in watt-hours during the same period, as determined using the applicable test method in the Appliance Efficiency Regulations.

SEMI-CONDITIONED SPACE

is an enclosed nonresidential space that is provided with wood heating, cooling by direct or indirect evaporation of water, mechanical heating that has a capacity of 10 Btu/(hr ft^2) or less, mechanical cooling that has a capacity of 5 Btu/(hr ft^2 or less, or is maintained for a process environment as set forth in the definition of DIRECTLY CONDITIONED SPACE.

SERVICE WATER HEATING

is heating of water for sanitary purposes for human occupancy, other than for comfort heating.

SHADING

is the protection from heat gains because of direct solar radiation by permanently attached exterior devices or building elements, interior shading devices, glazing material, or adherent materials. Permanently attached means (a) attached with fasteners that require additional tools to remove (as opposed to clips, hooks, latches, snaps, or ties); or (b) required by the UBC for emergency egress to be removable from the interior without the use of tools.

SHADING COEFFICIENT (SC)

is the ratio of the solar heat gain through a fenestration product to the solar heat gain through an unshaded 1/8 inch thick clear double strength glass under the same set of conditions. For nonresidential, high-rise residential, and hotel/motel buildings, this shall exclude the effects of mullions, frames, sashes, and interior and exterior shading devices.

SITE SOLAR ENERGY

is natural daylighting, or thermal, chemical, or electrical energy derived from direct conversion of incident solar radiation at the building site.

SKYLIGHT

is glazing having a slope less than 60 degrees from the horizontal with conditioned space below, except for purposes of complying with Section 151(f), where a skylight is glazing having a slope not exceeding 4.76 degrees (1:12) from the horizontal.

SKYLIGHT AREA

is the area of the surface of a skylight, plus the area of the frame, sash, and mullions.

SKYLIGHT TYPE

is a skylight assembly having a specific solar heat gain coefficient, whether translucent or transparent, and U-factor.

SOLAR HEAT GAIN COEFFICIENT (SHGC)

is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

SOURCE ENERGY

is the energy that is used at a site and consumed in producing and in delivering energy to a site, including, but not limited to, power generation, transmission, and distribution losses, and that is used to perform a specific function, such as space conditioning, lighting or water heating. Table 1-B contains the conversion factors for converting site to source energy.

SOUTH-FACING

is oriented to within 45 degrees of true south including 45^{o}00’00" west of south (SW), but excluding 45^{o}00’00" east of south (SE).

SPA

is a vessel that contains heated water, in which humans can immerse themselves, is not a pool, and is not a bathtub.

SPACE CONDITIONING SYSTEM

is a system that provides either collectively or individually heating, ventilating, or cooling within or associated with conditioned spaces in a building.

SMACNA

is the Sheet Metal and Air-conditioning Contractors National Association.

STAIRS, ACTIVE/INACTIVE

is a series of steps providing passage from one level of a building to another.

SUPPORT AREA

is a room or area used as a passageway, utility room, storage space, or other type of space associated with or secondary to the function of an occupancy that is listed in these regulations.

SYSTEM

is a combination of equipment, controls, accessories, interconnecting means, or terminal elements, by which energy is transformed to perform a specific function, such as space conditioning, service water heating, or lighting.

TASK-ORIENTED LIGHTING

is lighting that is designed specifically to illuminate a task location, and that is generally confined to the task location.

THEATER, MOTION PICTURE

is an assembly room, hall, or building with tiers of rising seats or steps for the showing of motion pictures.

THEATER, PERFORMANCE

is an assembly room, hall, or building with tiers of rising seats or steps for the viewing of dramatic performances, lectures, musical events and similar live performances.

THERMAL MASS

is solid or liquid material used to store heat for later heating use or for reducing cooling requirements.

THERMAL RESISTANCE (R)

is the resistance of a material or building component to the passage of heat in (hr x ft^2 x ^oF)/Btu.

THROW DISTANCE

is the distance between the luminaire and the center of the plane lit by the luminaire on a display.

TUNING

is a lighting control device that allows authorized personnel only to select a single light level within a continuous range.

UBC

is the 1994 edition of the state-adopted Uniform Building Code.

UL

is the Underwriters Laboratory.

UMC

is the 1997 edition of the state adopted Uniform Mechanical Code.

UNCONDITIONED SPACE

is enclosed space within a building that is not directly conditioned, indirectly conditioned or semi-conditioned space.

UNIT INTERIOR MASS CAPACITY (UIMC)

is the amount of effective heat capacity per unit of thermal mass, taking into account the type of mass material, thickness, specific heat, density and surface area.

U-FACTOR

is the overall coefficient of thermal transmittance of a construction assembly, in Btu/(hr x ft^2 x ^oF), including air film resistance at both surfaces.

VAPOR BARRIER

is a material that has a permeance of one perm or less and that provides resistance to the transmission of water vapor.

VARIABLE AIR VOLUME (VAV) SYSTEM

is a space conditioning system that maintains comfort levels by varying the volume of conditioned air to the zones served.

VERY VALUABLE MERCHANDISE

is rare or precious objects, including, but not limited to, jewelry, coins, small art objects, crystal, china, ceramics, or silver, the selling of which involves customer inspection of very fine detail from outside of a locked case.

VISIBLE LIGHT TRANSMITTANCE (VLT)

is the ratio (expressed as a decimal) of visible light that is transmitted through a glazing material to the light that strikes the material.

VOCATIONAL ROOM

is a room used to provide training in a special skill to be pursued as a trade.

WALL TYPE

is a wall assembly having a specific heat capacity, framing type, and U-factor.

WELL INDEX

is the ratio of the amount of visible light leaving a skylight well to the amount of visible light entering the skylight well and is calculated as follows:

(a) for rectangular wells:

$$\left(\frac{\text{Well height }(\text{well length} + \text{well width})}{2 \times \text{well length} \times \text{well width}}\right)$$

; or

(b) for irregular shaped wells:

$$\left(\frac{\text{Well height} \times \text{well perimeter}}{4 \times \text{well area}}\right)$$

WEST-FACING

is oriented to within 45 degrees of true west, including 45°00’00" north of due west (NW), but excluding 45°00’00" south of west (SW).

WINDOW

is glazing that is not a skylight.

WINDOW AREA

is the area of the surface of a window, plus the area of the frame, sash, and mullions.

WINDOW TYPE

is a window assembly having a specific solar heat gain coefficient, relative solar heat gain, and U-factor.

WINDOW WALL RATIO

is the ratio of the window area to the gross exterior wall area.

WOOD HEATER

is an enclosed wood burning appliance used for space heating and/or domestic water heating, and which meets the definition in Federal Register, Volume 52, Number 32, February 18, 1987.

WOOD STOVE

(See WOOD HEATER).

ZONE, LIGHTING

is a space or group of spaces within a building that has sufficiently similar requirements so that lighting can be automatically controlled in unison throughout the zone by an illumination controlling device or devices, and does not exceed one floor.

ZONE, SPACE CONDITIONING

is a space or group of spaces within a building with sufficiently similar comfort conditioning requirements so that comfort conditions, as specified in 144(b)3 or 150(h), as applicable, can be maintained throughout the zone by a single controlling device.

H. Residential Water Heating and Lighting

(Editor's Note: Appendix H is a combination of the Lighting portion of Chapter 2 and all of Chapter 6, Water Heating, from the **Residential Manual**. References found in this appendix are a part of the **Residential Manual**.)

Water Heating Summary

This chapter explains the relationship of water heating energy to the overall *Energy Efficiency Standards* (hereafter standards) compliance for a building. The Introduction briefly summarizes the *Water Heating Calculation Method* and explains when calculations and forms are required. This is followed by a more detailed discussion of the Basic Approach to the Method and step-by-step instructions on how to complete the water heating forms. Case studies outline the requirements for common and unusual water heating systems. Separate calculations and forms are explained for hydronic space and water heating systems. The chapter concludes with detailed descriptions of system components and installation criteria.

Chapter Overview:

Applicable sections of the California Code of Regulations, Title 24, Part 6: §150(j), 151(b), 151(f)8, 152.

Introduction

Water heating energy use is important because it accounts for about a quarter of residential energy consumption, as illustrated in Figure 6-1. This is the same percentage used statewide for residential space heating, and six times the amount used for residential cooling. Water heating energy may be an even higher percentage of the total energy consumption in small residences with lower space heating and cooling requirements.

Figure 6-2 shows the general flow of energy from the fuel source through the water heating system to the end use in the building. *Total energy in* is a combination of source energy plus any auxiliary inputs, which equals total energy out. *Total energy out* includes energy lost through electric power generation and transmission to the residence, water heater recovery efficiency and standby loss, distribution system losses and finally, hot water delivered to fixtures and appliances (see *Source Energy* in the *Glossary*).

Figure 6-1– Largest Residential Energy End

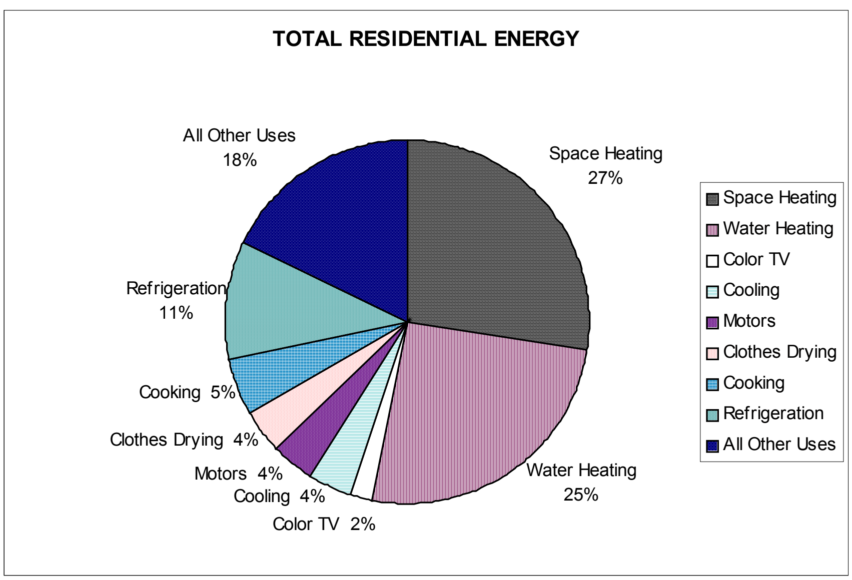
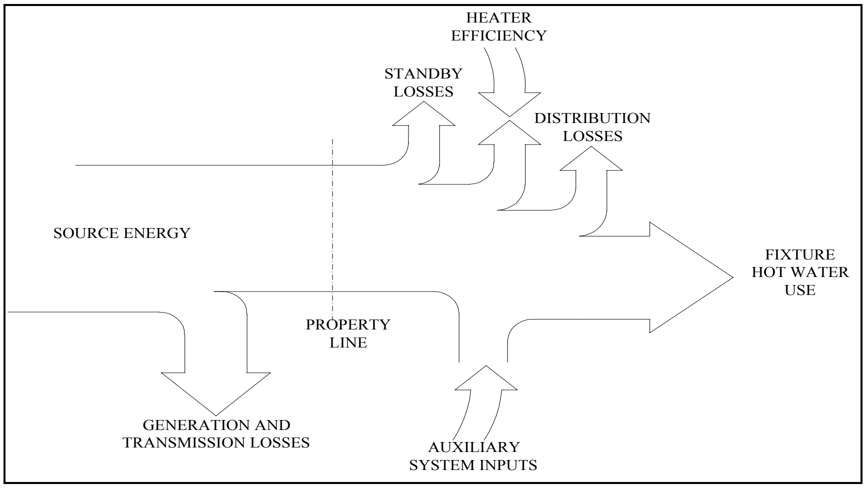


Figure 6-2– Water Heater System Energy Flow Diagram



Energy Factor is a measure used for *Heater Efficiency* for most water heaters used in single family dwellings and includes standby losses, recovery efficiency (the ratio of energy output used to heat the water divided by energy input), and the tank volume. More efficient water heaters have a higher EF.

Standby Loss accounts for energy lost while storing heated water. It includes heat losses through the water heater tank walls, fittings and flue, if any, plus any pilot light energy. Standby loss depends on the design and insulation of the water heater, as well as the difference between the temperature of the water and that of the air around the tank. Water heating energy use can be reduced by decreasing standby loss. This can be done by selecting a more efficient heater.

The water heater efficiency rating for small water heaters used in the water heating calculation method is the ***Energy Factor*** (EF) which combines tank volume, internal insulation, recovery efficiency and standby loss. The higher the EF the more efficient the water heater.

Recovery energy is the energy used to heat water, including the inefficiency (or efficiency loss) of the heater.

Recovery load is the amount of energy in hot water that the water heater needs to provide. It includes only the energy in the hot water that is used by the building occupant and the distribution losses.

Standby loss is over a quarter of a gas storage type water heater system's total energy use. When the system fuel is natural gas, there are no generation or transmission losses as are associated with electricity. Fuel type is very important in determining water heating energy use. While natural gas, LPG or oil can be burned directly to heat water, electricity is typically generated in a power plant far from the residence and then transmitted over power lines to the final end use. Approximately two thirds of the source energy used to generate electricity is lost in this process.

Any electric water heating system must automatically account for the inefficiency of the fuel type. Standard electric water heaters are not considered energy efficient for this reason.

Electric heat pump water heaters, however, are closer to the efficiency of typical gas systems, because they use the outdoor air as a heat source in heating water (see *Heat Pump* in the *Glossary*).

See Table 6-1A and Section 6.6 for more information on water heater types.

All water heating systems must meet the mandatory measures explained in Chapter 2, and all water heaters installed in California must be certified to the Commission (see Section 2.6 and 1.6). Several values that are needed in the water heating method are listed in this directory.

Water Heating Calculation Method Compliance/ Plan Check

The water heating calculation method estimates the amount of source energy used by any water heating system (the *Proposed Energy Use*) and compares it to the energy budget for water heating established by the standards (the *Standard Energy Use*). Sections 6.2 and 6.3 give detailed information and instructions on using the water heating calculation method. Section 6.3 includes blank copies of the various forms and the tables used in the calculations.

The calculation method looks at three components of each water heating system:

- Water Heater Type
- Auxiliary Input (nondepletable energy sources)
- Distribution System Type

Water Heater Type

Water heater types that can be analyzed using the water heating calculation method are:

- Standard Water Heater
- Storage Gas
- Large Storage Gas
- Storage Electric
- Storage Heat Pump
- Instantaneous Gas

- Instantaneous Electric
- Indirect Gas
- Oil-Fired

See Table 6-1A for brief descriptions of each water heater type and Section 6.6 for more detailed descriptions plus installation criteria.

Auxiliary Inputs

Auxiliary inputs are other energy sources that contribute to overall water heating. The calculation method allows water heating credits for two auxiliary input types that save energy by using nondepletable energy sources:

- Passive and Active Solar Water Heaters
- Wood Stove Boilers

See Table 6-1B for brief descriptions of each auxiliary input type and Section 6.6 for more detailed descriptions plus installation criteria.

Table 6-1A – Summary of System Components: Water Heaters

Water Heaters and Related Components	***Description***
Standard Water Heaters	Storage gas water heaters, 50 gallons or less (R-12 external insulation is a mandatory requirement for any water heater with an EF of less than 0.58).
Storage Gas	A gas water heater with a storage capacity of two gallons or more and a rated input of 75,000 Btu/hr or less.
Large Storage Gas	A storage gas water heater with greater than 75,000 Btuh input.
Storage Electric	An electric water heater with a storage capacity of two gallons or more.
Storage Heat Pump	An electric water heater that uses a compressor to transfer thermal energy from one temperature level to a higher temperature level for the purpose of heating water.
Instantaneous Gas	A gas water heater that heats water on demand rather than storing preheated water in a tank. Manufacturer's specified storage capacity must be less than two gallons.
Instantaneous Electric	An electric water heater that heats water on demand rather than storing preheated water in a tank. Manufacturer's specified storage capacity must be less than two gallons.
Indirect Gas	A water heater consisting of a storage tank with no heating elements or combustion devices, connected via piping and recirculating pump to a heat source typically consisting of a gas or oil fired boiler.

Table 6-1B – System Component Descriptions: Auxiliary Inputs

Auxiliary Systems	***Description***
Passive Solar Water Heaters	Systems which collect and store solar thermal energy for domestic water heating applications and do not require electricity to recirculate water through a solar collector.
Active Solar Water Heaters	Systems which collect and store solar thermal energy for domestic water heating applications requiring electricity to operate pumps or other components.
Wood Stove Boilers	Wood stoves equipped with heat exchangers for heating domestic hot water (see Figure 6-8).

Distribution System

The water heating *distribution system* is the configuration of piping, pumps and controls which regulates delivery of hot water from the water heater to all end uses within the building. The water heating method gives credits for especially energy-efficient distribution systems, such as non-recirculating systems with pipe insulation, while assigning penalties for less energy-efficient systems, such as continuous recirculation systems with no controls (see Table 6-3).

Distribution systems that may be analyzed are:

- Standard Distribution System
- Point of Use
- Hot Water Recovery
- Pipe Insulation
- Parallel Piping
- Recirculation: Continuous
- Recirculation: Temperature Controlled
- Recirculation: Time Controlled
- Recirculation: Time & Temperature Controlled
- Recirculation: Demand Pumping
- Combined Credits

Table 6-1C gives brief definitions of all of the distribution system types listed above, while Section 6.6 describes the systems in more detail and explains any required installation criteria.

When are Water Heating Forms Required?

Water heating forms must be provided only for non-standard systems that are not listed in Chapter 3 (for Prescriptive Packages). Table 6-2 summarizes when water-heating forms are required within the different compliance approaches.

Standard Water Heating Systems

If a proposed water heating system in a single family residence has no more than one *standard water heater* (as defined below) with a *standard distribution system*, then the water heating system need not be analyzed, but may be assumed to meet the water heating energy budget without requiring any additional forms or calculations. Compliance is demonstrated by simply listing the water heater on the Certificate of Compliance (CF-1R) Form.

The following water heater type is considered a *standard water heater:* storage gas water heater, 50 gallons or less, with a standard distribution system.

Note: Any storage heat pump water heater, 50 gallons or less, with an EF of at least 1.8 in Climate Zones 1-15, or at least 2.6 in Climate Zone 16, and a standard distribution system meets the water heating energy budget.

Table 6-1C – System Component Descriptions: Distribution Systems

Distribution Systems	***Description***
Standard	Standard system without any pumps for distributing hot water
Point of Use	System with no more than 8 feet horizontal distance between the water heater and hot water fixtures, except laundry. (Not used with central systems in multi-family buildings.)
Hot Water Recovery	System which reclaims hot water from the distribution piping by drawing it back to the water heater or other insulated storage tank. (Not used with central systems in multi-family buildings.)
Pipe Insulation	R-4 (or greater) insulation applied to 3/4 inch or larger, non-recirculating hot water mains in addition to insulation required by the standards, §150(j) (first five feet from water heater on both hot and cold water pipes).
Parallel Piping	Individual pipes from the water heater to each point of use.
Recirculation: Continuous	Distribution system using a pump to recirculate hot water to branch piping though a looped hot water main with no control of the pump, such that water flow is continuous. (Not used with instantaneous water heaters.) Pipe insulation is required.
Recirculation: Temperature	Recirculation system that uses temperature controls to cycle pump operation to maintain recirculated water temperatures within certain limits. (Not used with instantaneous water heaters.) Pipe insulation is required.
Recirculation: Time	Recirculation system that uses a timer control to cycle pump operation based on time of day. (Not used with instantaneous water heaters or with central systems in multi-family buildings.) Pipe insulation is required.
Recirculation: Time/Temp	Recirculation system that uses both temperature and timer controls to regulate pump operation. (Not used with instantaneous water heaters or with central systems in multi-family buildings.) Pipe insulation is required.
Recirculation: Demand	Recirculation system that uses brief pump operation to recirculate hot water to fixtures just prior to hot water use when a demand for hot water is indicated. (Not used with instantaneous water heaters or with central systems in multi-family buildings.)
Recirculation/Demand w/ Hot Water Recovery	Combined system consisting of Recirculation: Demand and Hot Water Recovery (Not used with instantaneous water heaters or with central systems in multi-family buildings).
Recirculation/Demand w/ Pipe Insulation	Combined system consisting of Recirculation: Demand and Pipe Insulation (Not used with instantaneous water heaters or with central systems in multi-family buildings).

A *standard distribution system* is one which does not incorporate a pump to recirculate hot water, and does not take credit for any special design features. A distribution system normally eligible for energy credits, such as one with pipe insulation, may be modeled as standard (i.e., no credits) to avoid water heating calculations.

See Section 6.6 for more detailed descriptions of standard water heaters and distribution systems, including installation criteria.

Table 6-2 – When Are Water Heating Forms Required?

	Water Heating System Type		
Compliance Method	Standard	Pre-Calculated Non-Standard	Other Non-Standard
Prescriptive Packages	No	No [1,2]	Yes[4]
Performance Method[4]	No	n/a	No 1,4

Notes:

1 No water heating forms are required, except to document solar collector systems and/or wood stoves.

2 Pre-calculated non-standard systems are listed in Chapter 3.

3 Approved programs perform water heating calculations internally; forms need not be submitted.

See Table 6-4 and Table 6-5 for a summary of water heating forms and compliance scenarios.

Pre-Calculated Non-Standard Systems

To simplify compliance with the prescriptive packages the Commission has developed lists of non-standard water heating systems that may be used without submitting water heating calculations. Systems pre-calculated and shown to meet or exceed the efficiency of a standard system are found in Table 3-13 through Table 3-17.

Approved Computer Methods

Approved computer programs perform water heating calculations internally, making water heating compliance forms unnecessary. However, other documentation may be required to support water heating credits for auxiliary inputs or other unique system components used for compliance.

Water Heating Calculations And Energy Compliance

The basic structure of the water heating calculation method is to:

(1) Calculate the *Proposed Energy Use* of the proposed water heating system

(2) Determine the *Standard Energy Use* (the energy budget)

(3) Compare the *Proposed Energy Use* to the *Standard Energy Use*

Prescriptive Packages

When demonstrating energy compliance for a building using the Prescriptive Packages, the proposed energy use for a water heating system must be less than the standard energy budget (Section 3.7). This requirement may be met by:

- Installing a standard water heating system;
- Installing an approved non-standard system as listed in Table 3-13 through Table 3-17; or,
- Completing the calculations and forms contained in Section 6.3 to verify that the proposed energy use is less than the standard energy use.

Performance Methods

When demonstrating energy compliance for a building using an approved performance method, the building's total (combined) space conditioning and water heating energy consumption cannot exceed the sum of the total space conditioning and water heating energy budgets (Section 4.2).

When using an approved computer program, water heating compliance is calculated internally within the program.

If the building has a standard water heating system as defined above, the Proposed Energy Use is equal to the Standard Energy Use in the performance methods.

Water Heating Calculations For Additions

There are three typical situations for water heating systems in building additions:

1. The addition uses the existing water heating system. No new water heater is added. If no new water heater is added, the addition may be analyzed by itself without requiring water heating calculations. If the addition is analyzed using the existing-plus-addition method (performance), then either the existing water heating system may be modeled as is or it may be assumed to be a standard water heating system (see Section 6.3 - use the same modeling assumptions for all calculations).

2. A new water heater, installed to replace the existing water heater, serves the entire existing building plus the addition, and there is no increase in the number of water heaters in the building. In this case

water heating calculations are not required because the total number of water heaters does not increase. The new water heater serves as a replacement; for the purpose of compliance analysis, it may be assumed to be a standard water heater.

3. A new water heater (or heaters) is added with the addition, resulting in an increase in the number of water heaters (see below).

§ 152(a), Exception No. 3

Additions that Increase the Total Number of Water Heaters

If the addition will increase the total number of water heaters in the building, one of the following types of water heaters may be installed to comply with Section 152(a)1. or Section 152(a)2.A, and Section 152 (c):

(1) A gas storage non-recirculating water heating system that does not exceed 50 gallons capacity; or

(2) If no natural gas is connected to the building, an electric storage water heater that does not exceed 50 gallons capacity, has an energy factor not less than 0.90; or

(3) A water heating system determined by the Executive Director to use no more energy than the one specified in (1) above; or if no natural gas is connected to the building, a water heating system determined by the Executive Director to use no more energy than the one specified in (2) above.

For prescriptive compliance with Section 152(a)1., the water heating systems requirement in Section 151(f)8. shall not apply. For performance compliance for the addition alone, only the space conditioning budgets of Section 151(b)2. shall be used; the water heating budgets of Section 151(b)1. shall not apply. The performance approach for the existing building and the addition in Section 152(a)2.B may be used to show compliance, regardless of the type of water heater installed.

When there is an increase in the number of water heaters, the addition may be analyzed using any of the compliance approaches under certain conditions. Addition alone compliance may be used if:

(a) The additional water heater is either a 50 gallon or less, gas storage, nonrecirculating water heater or equivalent (see Section 7.2) that also meets the mandatory requirements (see Chapter 2);

(b) The home does not have natural gas available and the additional water heater is either a 50-gallon or less electric water heater with an EF of 0.90 or greater or equivalent (see Section 7.2);

(c) If the conditions in (a) or (b) are met, water heating calculations are not required with any of the compliance approaches, and no credit or penalty is allowed. Computer compliance calculations will show proposed energy use for water heating to be equal to standard energy use.

Existing-plus-addition compliance may be used when a new water heating system is proposed which is not described in (a) and (b) above, is not found in Section 7.2, or to take credit for a more efficient water heating system.

See Examples 6-8, 6-9 and 6-12 in Section 6.4, and Chapter 7 for more information on compliance of water heaters associated with additions.

Water Heating Inspection

Check that the number and types of water heater systems installed, as indicated on the CF-6R and check to see that this corresponds to the approved CF-1R. The distribution system is also significant and must correspond to plan specifications. For example:

- If the plans indicate the presence of a hot water recovery system, it must be installed.
- If a recirculation system is installed, verify that it was accounted for in the compliance documentation (CF-1R) and check for any required controls (e.g., demand pump, timer).
- If a point of use credit is specified, the water heater must be no further than 8 feet from all hot water outlets (excluding washing machines).

The chart below summarizes the different distribution system types and lists whether each one is a credit or a penalty as compared with the standard distribution system.

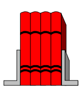
Verify the make and model number of the installed water heater unit matches that listed on the Installation Certificate (CF-6R).

If the water heater has an EF of less than 0.58, an R-12 water heater blanket is required (internal insulation cannot be used to satisfy this mandatory requirement). For water heaters with 0.58 EF or higher, no insulation blanket is required. The blanket should be securely attached around the water heater. The top of the water heater should not be insulated and a cutout in the blanket should be provided for combustion air intake.

Table 6-3 – Water Heating Distribution System Credits and Penalties

Distribution System	***Credit or Penalty***
Hot Water Recovery	Credit
Point of Use	Credit
Pipe Insulation	Credit
Parallel Piping	Credit
Recirculation:	
No Control	Penalty
Time	Penalty
Temperature	Penalty
Time/Temperature	Credit
Demand	Credit

Basic Approach



§151(b)1

Water Heating Budget

Water heating budgets. The budgets for water heating systems are those calculated from:

Equation 6-2

ANNUAL WATER HEATING BUDGET (AWB):
For dwelling units less than 2500 ft²:

$$AWB\ (kBtu/yr.\text{-}ft^2) = \frac{(16370) + 4.85}{CFA}$$

For dwelling units equal to or greater than 2500 ft²:

$$AWB\ (kBtu/yr.\text{-}ft^2) = \frac{(26125)}{CFA}$$

Where CFA = the building's conditioned floor area in square feet.
The annual water heating budget calculated from Equation No. 1-N may be met by either:
A. Calculating the energy consumption of the proposed water heating system using an approved calculation method without an external insulation wrap or
B. Installing any gas storage type non-recirculating water heating system that does not exceed 50 gallons of capacity, and that meets the minimum standards specified in the Appliance Efficiency Standards.

Note: Storage gas water heaters with an energy factor of less than 0.58 must be externally wrapped with insulation having an installed thermal resistance of R-12 or greater in accordance with §150(j).

As outlined in Section 6.1, the water heating method involves the calculation of the *Proposed Energy Use* of the proposed system, and the determination of the *Standard Energy Use* for the dwelling unit being analyzed (see form DHW-1).

The standard water heating energy use per dwelling unit is dependent on the total conditioned floor area of the dwelling unit. Allowable water heating energy use per dwelling unit increases with an increase in floor area. However, 26,125 kBtu/yr-unit is the maximum standard water heating energy use for dwelling units larger than 2,500 square feet (§151(b)1 of the standards).

Standard energy use is assumed to be climate-independent. It is based on the energy use of a federally rated minimum efficiency 50 gallon gas water heater (EF 0.525) with a standard distribution system (see Section 6.6).

Presented as a hand method in this chapter, water heating calculations use a series of forms and tables included at the end of Section 6.3. The forms and tables used are selected according to the specific proposed water heating system. Tables 6-3 and 6-4 summarize the forms as well as their application in a range of compliance situations.

The water heating method can be used to analyze water heating energy use of:

- A specific single dwelling unit;
- An average dwelling unit in a multi-family building; or,
- Each different dwelling unit in a multi-family building.

Note: When multi-family water heaters are *shared* by more than one dwelling unit, compliance must be based on the average of the square feet of the dwelling units served by each (different) shared water heater.

Table 6-4 – Summary of Water Heating Forms

Number	***Name/Function***	***Application***
DHW-1	Water Heating Worksheet	Non-standard water heating system
DHW-2A	Water Heating for Single Family w/ Multiple Heaters	Single-family dwelling unit with more than one water heater
DHW-2B	Water Heating for Multi-Family	Multi-family building
DHW-3	Large or Indirect Water Heater	Large Storage Gas or Indirect Gas heater Worksheet(see Section 6.6)
DHW-4	Removed (incorporated into DHW-1)	Solar and wood heating calculations
DHW-5	Combined Hydronic Space and Water Heating	Hydronic system serving both space heating and water heating (see Section 6.5)

Table 6-5 – Summary of Compliance Scenarios

Compliance Scenario		***Forms Submitted***
a.	One Standard System Per Dwelling Unit	None
b.	Pre-Calculated System (see Chapter 3)	None
c.	One Non-standard System Per Dwelling Unit(other than pre-calculated systems)	DHW-1
d.	Single Family Dwelling w/Multiple Heaters(other than pre-calculated systems)	DHW-1, DHW-2A
e.	Multi-Family Building	DHW-1, DHW-2B
f.	Solar or Wood Stove (Auxiliary Input)	DHW-1
g.	Combined Hydronic Space and Water Heating	DHW-5
h.	Additions (see Chapter 7)	Same as a, b, c, d, e, f or g above

The compliance methodology has three steps:

1. Determine the *Adjusted Recovery Load* to be satisfied by the water heating system. The *Standard Recovery Load* (from Table 6-6) may be modified by *distribution piping system credits or penalties* (from Table 6-3) and/or a *solar energy credit* (from DHW-1).
2. Determine the *Proposed Energy Use* of the water heating system. The *Basic Energy Use* (from Table Table 6-7 according to heater type) may be modified by a *wood stove boiler credit* (from DHW-1).
3. Determine the *Standard Energy Use* of the dwelling unit(s) (from Table 6-6).

Water heating compliance depends on a comparison of the Proposed Energy Use and the Standard Energy Use:

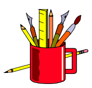
- Prescriptive: The Proposed Energy Use must be less than or equal to the Standard Energy Use for compliance of the water heating system.

- Performance Methods: The difference between Proposed and Standard Water Heating Energy Use is either a *credit* resulting in a *lower kBtu/sf-yr* of total proposed energy use, or a *penalty* resulting in a *higher kBtu/sf-yr* of total energy use.

Water Heating in the Performance Methods

Using the performance approach, *energy tradeoffs* can be made between water heating and space conditioning energy use. If the proposed water heating energy use is greater than the standard energy use, the water heating system and building comply as long as the total proposed design energy use, in kBtu/sf-yr, is the same or less than the total standard design energy budget using a computer method as explained in Chapter **5**.

Instructions, Forms & Tables



The instructions presented in this part provide a step-by-step description for each worksheet and form. To see completed sample worksheets for different water heating systems, see Section 6.4. For an overview of which forms apply to which compliance scenarios, refer to Table 6-4.

The worksheet for Combined Hydronic Space and Water Heating, DHW-5, is contained in Section 6.5.

Heater type data is contained in the Commission's listing of certified water heaters. Data on water heaters, for use with a database program is also available from the Commission's Web site at: www.energy.ca.gov/appliance

DHW-1, Water Heating Worksheet

Complete the DHW-1 form whenever there is a non-standard water heating system (see Sections 6.1 and 6.6). You may calculate up to three different heater types per sheet. If you have more than three different types, use additional copies of the worksheet.

The section of the worksheet entitled *Energy Use Calculation* refers to tables included at the end of this part.

Title Block

- Enter **Project Title** and **Date**.
- Enter the **Number of Different Water Heater Types** (this value may not necessarily be the same as the *total* number of individual water heaters in the building.)
- Enter the **Total No. of Water Heaters**.
- Enter the total **Conditioned Floor Area (CFA)** of the dwelling unit, in square feet. When multi-family water heaters are *shared* by more than one dwelling unit, compliance must be based on the average of the square feet of the dwelling units served by each (different) shared water heater. Enter this average dwelling unit CFA here.

Heater Type Data

For each column, enter the heater number (e.g., "Heater # 1 Data".) To identify which water heater on the plans matches these calculations.

A. Indicate the **Water Heater Type**. For a full listing of heater type descriptions and installation criteria, see Section 6.6. If the water heater is part of a hydronic system, see Section 6.5.

Note: Oil-fired water heaters are considered gas water heaters for the purpose of the water heating calculations.

List the Manufacturer.

C. List the Model No.

The next set of values (lines D, E, F and G) must be taken from the Commission's listing of Certified Water Heaters.

D. Enter the Energy Factor. If Indirect Gas or Large Gas Storage water heater, leave blank.
E. Enter the actual capacity of the heater in Gallons.
F. For Instantaneous Gas heater type, enter Pilot Btu/hr.
G. For Instantaneous Gas heater type only, enter Thermal (Recovery) Efficiency (also used on form DHW-3).

H. Renewable energy sources such as solar or a wood stove are considered Auxiliary Input to the system. Indicate with a checkmark if either applies. For a full description of auxiliary inputs, see Section 6.6.
I. Indicate the Distribution System. For a full listing of distribution descriptions and installation criteria, see Section 6.6. If the distribution system is part of a hydronic system, see Section 6.5.

Energy Use Calculation

All values entered in lines 1a, 1b, 1d, 1e, 2a, 2c, 2d and 3 are in million Btu/year per dwelling unit (MBtu/yr-unit).

1a. Enter the **Standard Recovery Load** from Table 6-5 based on the total conditioned floor area of the dwelling unit.
1b. For a "Standard" distribution system, enter zero (0).

For other distribution system types, select **Distribution Credit** (+) or **Penalty** (-) from Table 6-6A or 6-6B based on standard recovery load (line 1a).

Pipe insulation credit can only be taken with nonrecirculating systems and demand recirculating systems.

1c. If there is a solar Auxiliary Input (line H), then use the conditioned floor area and a solar energy factor to select the **Solar Fraction** from Table 6-8. Otherwise, enter zero (0).

All solar water heating devices must be Solar Rating and Certification Corporation (SRCC) rated. A pre-approved solar water heating system includes the collectors and water heater. The SRCC may be contacted at:

Solar Rating and Certification Corporation
C/o FSEC, 1679 Clearlake Road
Cocoa, FL 32922-5703
(407) 638-1537
(407) 638-1010 (FAX)

1d. Multiply the Standard Recovery Load (Line 1a) with the Solar Fraction (Line 1c) to calculate the **Solar Energy Credit**.
1e. Subtract credits to calculate the **Adjusted Recovery Load** (subtract lines 1b and 1d from line 1a). Note that when line 1b is negative, line 1d increases.
2a. Based upon the Water Heater Type (line A), find the **Basic Energy Use** as follows:

Storage Gas	Table 6-7A
Storage Electric	Table 6-7B
Storage Heat Pump	Table 6-7C
Instantaneous Gas	Table 6-7D
Instantaneous Electric	Table 6-7D
Indirect Gas	DHW-3
Large Storage Gas	DHW-3

The tables use values listed on this worksheet such as Energy Factor (line D), Adjusted Recovery Load (line 1e), Pilot Btu/hr and Recovery Efficiency.

Note: No interpolation is allowed in Table 6-7. Go into the rows and columns in those tables using the table values closest to the actual values.

2b. If there is a wood stove Auxiliary Input (line H), determine the **Wood Stove Boiler Credit Factor** from Table 6-9. Otherwise, enter zero (0).

Wood Stove Boiler credit factors in Table 6-11 vary by climate zone and may be used to compute the wood stove boiler credit with or without a recirculating pump. DHW-1 must be completed through line 2a before WSB credit is computed.

Note: As tabulated in Table 6-11, the credit for Wood Stove Boilers with recirculating pumps is 90 percent of the credit without pumps based on a base case 85 watt pump applied to a 1700 ft^2 house and adjusted for electric source energy.

2c. Multiply the Basic Energy Use (Line 2a) with the Wood Stove Boiler Credit Factor (Line 2b) to calculate the **Wood Stove Boiler Credit**.
2d. Subtract the Wood Stove Boiler credit to calculate the **Proposed Energy Use** (subtract line 2c from line 2a).

Standard Energy Use

3. Find the **Standard Energy Use** from Table 6-5 using the total conditioned floor area of the dwelling unit. Enter the value on line 3.
4. In the prescriptive compliance approach (Section 3.7), *the proposed water heating system complies if line 2d is less than or equal to line 3*.

DHW-2A, Water Heating for Single Family with Multiple Heaters

If you are completing the DHW-1 form for a single family unit with more than one water heater, you must also complete the DHW-2A form.

Title Block

Enter **Project Title** and **Date**.

Single Family Project Data

1. Enter the **Number of different water heater types** (this may not necessarily be the same as the *total* number of water heaters in the building.)
2. Enter the **Total conditioned floor area** of the dwelling unit.

3a, 3b & 3c.

Enter the **Number of Heaters** for each **Heater Number**, **Manufacturer** and **Model Number** listed on DHW-1.

4. The **Total Number of Water Heaters** is the sum of lines 3a, 3b and 3c.
5. Enter the **Standard Recovery Load** from Table 6-5 based on line 2, total conditioned floor area.
6. Calculate and enter the **Recovery Load per heater**, which is line 5 divided by line 4. Enter this value on DHW-1, line 1a, for each heater type. Complete DHW-1 calculations through line 2d for each heater type.
7. Calculate and enter the **Proposed Energy Use** for **Heater #1**, which is DHW-1 Heater #1 line 2d times line 3a.
8. Calculate and enter the **Proposed Energy Use** for **Heater #2**, which is DHW-1 Heater #2 line 2d times line 3b.
9. Calculate and enter the **Proposed Energy Use** for **Heater #3**, which is DHW-1 Heater #3 line 2d times line 3c.
10. Calculate and enter the **Total Proposed Energy Use**, which is the sum of lines 7, 8 and 9.
11. Enter the **Standard Energy Use** from Table 6-5 using line 2, total conditioned floor area.

Compliance

12. In the prescriptive compliance approach (see Chapter 3), the proposed water heating system complies if line 10 is equal to or less than line 11.

DHW-2B, Water Heating for Multi-Family

Complete the DHW-2B form for any multi-family project. The DHW-1 worksheet must also be completed whenever the DHW-2B form is submitted.

Title Block

Enter **Project Title** and **Date**.

Multi-Family Project Data

1. Enter the Number of dwelling units.
2. Enter the Total conditioned floor area of the building.
3. Calculate and enter the Average floor area per dwelling unit, which is line 2 divided by line 1.
4. Indicate which analytical method is used to calculate Proposed Energy Use: Average Dwelling Unit or Individual Dwelling Unit. For "Individual Dwelling Unit" analysis, complete only lines 1 through 5, and attach a DHW-1 form with a Heater # for each individual unit.
5. Indicate which System configuration is being installed in the building: Individual Heaters (one per dwelling unit) or Shared Heaters (multiple dwelling units per heater).

If Individual Heaters, follow instructions for lines 9a through 11a.

If Shared Heater(s), complete lines 9b-13b, and follow instructions on line 13b.

6a, 6b, 6c & 6d.

Enter the **Number of Heaters** for each **Heater Number**, **Manufacturer** and **Model Number** listed. For Individual Heaters, also enter the volume in **Gallons** for **Each** heater, and for the **Total** number of heaters of that type; enter the **Energy Factor** for **Each** heater, and the **Total** value (which is the number of heaters times the EF). Enter the Thermal (Recovery) Efficiency for each heater and the Total value (number of heaters time the Thermal Efficiency.

7a. Enter the **Total** number of heaters, which is the sum of lines 6a, 6b and 6c.

The following items (lines 7b, 7c, 7d, 8a and 8b) are calculated only for Individual Heaters.

7b. Enter the **Total** gallons of all heaters.

7c. Enter the **Total** of the Energy Factors.

7d Enter the Total of the Thermal Efficiencies.

8a. Calculate and enter the **Average** gallons per heater, which is line 7b divided by line 7a.

8b. Calculate and enter the **Average** Energy Factor per heater, which is line 7c divided by line 7a.

8c. Calculate and enter the Average Thermal Efficiency per heater, which is line 7d divided by line 7a.

Individual Heaters

9a. Transfer the value from line 8a to DHW-1 line E (gallons).

10a. Transfer the value from line 8b to DHW-1 line D (Energy Factor).

11a. Transfer the value from line 8c to DHW-1 line G (Thermal Efficiency)

12. Check compliance on DHW-1 for average dwelling unit and average water heater.

Shared Heater(s)

9b. Calculate and enter the **Average Unit Recovery Load**, which is DHW-1 line 1e.

10b. Calculate and enter the **Total Adjusted Recovery Load**, which is line 1 times line 9b.

11b. Enter the **Basic Energy Use** from Table 6-7, or from DHW-3 line 9 based on line 10b.

12b. Calculate and enter the **Average Unit Building Energy Use**, which is transferred from DHW-1 line 2a.

13b. Verify compliance on DHW-1 for average dwelling unit.

14. In the prescriptive compliance approach (see Chapter 3), *the proposed water heating system complies if DHW-1 line 2d is less than or equal to DHW-1 line 3*.

DHW-3, Large Storage Gas or Indirect Gas Worksheet

Complete the DHW-3 for any project that includes a large storage gas heater or an indirect gas heater (as explained in Section 6.6). *The DHW-1 worksheet must also be completed whenever the DHW-3 form is submitted*.

Title Block

Enter **Project Title** and **Date**.

Indirect Gas Water Heaters

1. Enter the Storage tank Manufacturer and Model Number.
2. Enter the Boiler or Instantaneous Water Heater Manufacturer and Model Number.
3. Enter the Storage tank insulation R-value: The R-value integral with (internal to) the Tank; any External insulation R-value; and the Total of the two.
4. Enter the Storage tank volume in gallons.
5. Find the Boiler AFUE or Instantaneous Water Heater Recovery Efficiency in the appropriate appliance directory or database and enter on Line 5 in decimal fraction form (e.g., 0.78).
6. Enter the Adjusted Recovery Load on line 6 from DHW-1 Line 1e.
7. Using tank volume (Line 4) and Total R-Value (Line 5), determine Jacket Loss in MBtu/yr from Table 6-7E and enter on line 7.
8. Enter Pilot energy (Btu/hr) from appliance directory or database on line 8. Enter zero (0) for no pilot, or 800 if pilot exists but energy use is not listed in the appliance database.
9. Using the equation listed, calculate Basic Energy Use and enter the value on line 9. Also enter the value on DHW-1 Line 2a or DHW-2B Line 11b.

Large Storage Gas Water Heaters (>75,000 Btuh Input)

1. Enter the Water Heater Manufacturer.
2. Enter the Water Heater Model No.

3. Enter the actual Storage tank volume in gallons from the Appliance database.
4. Enter the Water Heater Thermal (Recovery) Efficiency from the appliance database and enter on Line 5 in decimal fraction form (e.g. 0.78).
5. Enter the Adjusted Recovery Load, from DHW-1 Line 1d or from DHW-2B Line 10b, on Line 6.
6. Enter Standby loss % from the appliance database on line 8. (For example, enter "3.2" for 3.2 percent.)
7. Using the equation listed, calculate Basic Energy Use and enter the value on line 9. Also, enter the value on DHW-1 Line 2a or on DHW-2b Line 11b.

DHW-5, Combined Hydronic Space and Water Heating

Complete the DHW-5 for any project that includes a combined hydronic space and water heating system (as explained in Sections 6.5 and 8.9) to calculate the AFUE. The DHW-5 is also used to calculate the adjusted AFUE (accounting for pipe losses) when a space heating boiler is also used for water heating. *The DHW-1 worksheet must also be completed whenever the DHW-5 form is submitted.*

If water heating is provided by a dedicated (separate) hydronic space heating system, complete the DHW-1 form only.

Storage Gas

1. Enter the Recovery Efficiency, Thermal Efficiency, or Annual Fuel Utilization Efficiency (AFUE) (decimal) of the water heater or boiler.
2. Enter the calculated Average Hourly Pipe Loss, from the Pipe Loss Worksheet on the bottom of the DHW-5 form.
3. Enter the Rated Input of the water heater.
4. Determine the Effective AFUE of the system, by first dividing Line 2 by Line 3, then subtracting that value from Line 1. This value is used for prescriptive compliance.

Storage Electric

1. Enter the calculated **Average Hourly Pipe Loss**, from the **Pipe Loss Worksheet** on the bottom of the DHW-5 form.
2. Enter the **Rated Input** of the water heater.
3. Enter the **Pump Watts** of the water heater and all other pumps associated with the system.
4. Calculate **Term A** from Lines 1 and 2. Multiply Line 2 by 3.413, then divide Line 1 by this value. Subtract the result from 1.
5. Calculate **Term B** from Lines 2 and 3. Multiply Line 3 by 1000, then divide Line 3 by this value, and add 1.
6. Calculate the **Effective HSPF (no fan)** by first dividing Line 4 by Line 5, then multiplying the result by 3.413. This value is used in the packages.
7. Calculate the **Effective HSPF (with fan)** by first dividing 1 by Line 6, then adding 0.005. Next divide the result into 1.017. This value is used in the packages.

Heat Pump

1. Enter the **Energy Factor** (decimal) of the water heater.
2. Enter the **Average Hourly Pipe Loss** from the **Pipe Loss Worksheet** on the bottom of the DHW-5 form.
3. Enter the **Rated Input** of the water heater.
4. Determine the **Recovery Efficiency** of the water heater. Divide 1 by Line 1, then subtract 0.1175. Divide the result into 1.
5. Enter the **Climate Zone Adjustment** value from the table on the form.
   Calculate the **Effective HSPF (no fan)** by first multiplying 3.413 by Line 3, then dividing this value into Line 2. Next subtract this value from the value resulting from dividing Line 4 by Line 5. Multiply this result by 3.413. This value is used in the packages.
7. Calculate the **Effective HSPF (with fan)** by first dividing 1 by Line 6, then adding 0.005. Next divide the result into 1.017. This value is used in the packages.

Pipe Loss Worksheet

1. Include **Description(s)** of any piping with more than 10 feet of pipe in unconditioned space between supply and distribution systems.

2. Enter **Pipe Loss Rate** for type(s) of pipe from table on the form.
3. Enter the **Pipe Length** of each pipe outside conditioned space.
4. Calculate **Total Pipe Loss** by multiplying pipe loss rate by pipe length.
   Sum all pipe losses from step 4.
6. Divide the value from step 5 by 8760 to determine the **Average Hourly Pipe Loss (kBtu/hr)**.

If the **Pipe Losses** section is not applicable (less than 10 feet of pipe in unconditioned space), enter zero for the **Average Hourly Pipe Loss**.

Table 6-6A – Standard Recovery Load and Standard Energy Use[1]

Floor Area	***Standard Recovery Load***	***Standard Energy Use***	***Floor Area***	***Standard Recovery Load***	***Standard Energy Use***
< 111	6.4	16.9	626 - 675	8.4	19.5
111 - 130	6.5	17.0	676 - 726	8.6	19.8
131 - 150	6.5	17.0	726 - 775	8.8	20.0
151 - 170	6.6	17.1	776 - 825	9.0	20.3
171 - 190	6.7	17.2	826 - 875	9.2	20.5
191 - 210	6.8	17.3	876 - 925	9.4	20.7
211 - 230	6.8	17.4	926 - 975	9.5	21.0
231 - 250	6.9	17.5	976 - 1050	9.8	21.3
251 - 270	7.0	17.6	1051 - 1150	10.1	21.7
271 - 290	7.1	17.7	1151 - 1250	10.5	22.2
291 - 310	7.1	17.8	1251 - 1350	10.9	22.7
311 - 330	7.2	17.9	1351 - 1450	11.3	23.2
331 - 350	7.3	18.0	1451 - 1550	11.6	23.6
351 - 370	7.3	18.1	1551 - 1650	12.0	24.1
371 - 390	7.4	18.2	1651 - 1750	12.4	24.6
391 - 410	7.5	18.3	1751 - 1850	12.8	25.1
411 - 430	7.6	18.4	1851 - 1950	13.2	25.6
431 - 450	7.6	18.5	1951 - 2050	13.6	26.1
451 - 470	7.7	18.6	2051 - 2150	14.0	26.6
471 - 490	7.8	18.7	2151 - 2250	14.4	27.0
491 - 525	7.9	18.8	2251 - 2350	14.8	27.5
526 - 575	8.0	19.0	2351 - 2500	15.3	28.1
576 - 625	8.2	19.3	> 2500	15.6	28.5

Table 6-6B – Standard Recovery Load and Standard Energy Use[1]

					Recirculation Systems				
Standard Recovery Load	**Standard**	**Point of Use**	**Hot Water Recovery**	**Parallel Piping**	**Time/Temp**	**Demand**	**Time**	**Temp**	**No Control**
< 6.3	0.0	1.1	1.1	0.9	0.3	0.1	-1.8	-0.3	-3.3
6.3 – 6.99	0.0	1.2	1.2	0.9	0.3	0.1	-1.8	-0.3	-3.4
7.0 – 7.49	0.0	1.3	1.3	1.0	0.3	0.1	-2.0	-0.4	-3.7
7.5 – 7.99	0.0	1.4	1.4	1.1	0.3	0.2	-2.2	-0.4	-4.0
8.0 – 8.49	0.0	1.5	1.5	1.1	0.3	0.2	-2.3	-0.4	-4.3
8.5 – 8.99	0.0	1.6	1.6	1.2	0.3	0.2	-2.4	-0.4	-4.5
9.0 – 9.49	0.0	1.7	1.7	1.3	0.4	0.2	-2.6	-0.5	-4.8
9.5 – 9.99	0.0	1.7	1.7	1.4	0.4	0.2	-2.7	-0.5	-5.0
10.0 - 10.99	0.0	1.8	1.8	1.4	0.4	0.2	-2.9	-0.5	-5.3
11.0 - 11.99	0.0	2.0	2.0	1.6	0.4	0.2	-3.1	-0.6	-5.8
12.0 - 12.99	0.0	2.2	2.2	1.7	0.5	0.2	-3.4	-0.6	-6.3
13.0 - 13.99	0.0	2.4	2.4	1.8	0.5	0.3	-3.7	-0.7	-6.9
14.0 - 15.99	0.0	2.6	2.6	2.0	0.6	0.3	-4.0	-0.7	-7.4
16.0 - 17.99	0.0	2.9	2.9	2.3	0.6	0.3	-4.5	-0.8	-8.4
18.0 - 19.99	0.0	3.3	3.3	2.5	0.7	0.4	-5.1	-0.9	-9.5
20.0 - 21.99	0.0	3.6	3.6	2.8	0.8	0.4	-5.7	-1.0	-10.5
22.0 - 23.99	0.0	4.0	4.0	3.1	0.9	0.4	-6.2	-1.1	-11.5
24.0 - 25.99	0.0	4.4	4.4	3.4	1.0	0.5	-6.8	-1.2	-12.6
26.0+	0.0	4.8	4.8	3.7	1.1	0.5	-7.4	-1.3	-13.7

Table 6-6C – Standard Recovery Load and Standard Energy Use[1]

Standard Recovery Load	Standard	Point of Use	Hot Water Recovery	Parallel Piping	Recirculation Systems Time/Temp	Demand	Time	Temp	No Control
< 6.3	0.0	0.0	0.0	0.9	-3.3	-3.3	-3.3	-0.3	-3.3
6.3 - 6.99	0.0	0.0	0.0	0.9	-3.4	-3.4	-3.4	-0.3	-3.4
7.0 - 7.49	0.0	0.0	0.0	1.0	-3.7	-3.7	-3.7	-0.4	-3.7
7.5 - 7.99	0.0	0.0	0.0	1.1	-4.0	-4.0	-4.0	-0.4	-4.0
8.0 - 8.49	0.0	0.0	0.0	1.1	-4.3	-4.3	-4.3	-0.4	-4.3
8.5 - 8.99	0.0	0.0	0.0	1.2	-4.5	-4.5	-4.5	-0.4	-4.5
9.0 - 9.49	0.0	0.0	0.0	1.3	-4.8	-4.8	-4.8	-0.5	-4.8
9.5 - 9.99	0.0	0.0	0.0	1.4	-5.0	-5.0	-5.0	-0.5	-5.0
10.0 - 10.99	0.0	0.0	0.0	1.4	-5.3	-5.3	-5.3	-0.5	-5.3
11.0 - 11.99	0.0	0.0	0.0	1.6	-5.8	-5.8	-5.8	-0.6	-5.8
12.0 - 12.99	0.0	0.0	0.0	1.7	-6.3	-6.3	-6.3	-0.6	-6.3
13.0 - 13.99	0.0	0.0	0.0	1.8	-6.9	-6.9	-6.9	-0.7	-6.9
14.0 - 15.99	0.0	0.0	0.0	2.0	-7.4	-7.4	-7.4	-0.7	-7.4
16.0 - 17.99	0.0	0.0	0.0	2.3	-8.4	-8.4	-8.4	-0.8	-8.4
18.0 - 19.99	0.0	0.0	0.0	2.5	-9.5	-9.5	-9.5	-0.9	-9.5
20.0 - 21.99	0.0	0.0	0.0	2.8	-10.5	-10.5	-10.5	-1.0	-10.5
22.0 - 23.99	0.0	0.0	0.0	3.1	-11.5	-11.5	-11.5	-1.1	-11.5
24.0 - 25.99	0.0	0.0	0.0	3.4	-12.6	-12.6	-12.6	-1.2	-12.6
26.0+	0.0	0.0	0.0	3.7	-13.7	-13.7	-13.7	-1.3	-13.7

1. Hot water recovery and pipe insulation credits may only be applied to non-recirculating systems and demand recirculating systems. All other recirculating systems must have pipe insulation as explained in Section 6.6.

*Table 6-7A – Basic Energy Use (BEU)** *- Storage Gas Heater [no interpolation]*

Adjusted Recovery Load	Energy Factor																						
	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.74	0.78	0.82
3.0	19.9	18.5	17.3	16.2	15.3	14.4	13.7	13.0	12.4	11.8	11.3	10.8	10.4	10.0	9.3	8.7	8.1	7.7	7.2	6.8	6.2	5.7	5.2
3.2	19.6	18.3	17.2	16.2	15.3	14.5	13.8	13.1	12.6	12.0	11.5	11.1	10.6	10.3	9.6	8.9	8.4	7.9	7.5	7.1	6.5	5.9	5.5
3.4	19.4	18.2	17.2	16.2	15.4	14.6	14.0	13.3	12.8	12.2	11.8	11.3	10.9	10.5	9.8	9.2	8.7	8.2	7.8	7.4	6.7	6.2	5.7
3.6	19.3	18.2	17.2	16.3	15.5	14.8	14.2	13.6	13.0	12.5	12.0	11.6	11.2	10.8	10.1	9.5	9.0	8.5	8.1	7.7	7.0	6.4	5.9
3.8	19.3	18.2	17.3	16.5	15.7	15.0	14.4	13.8	13.2	12.7	12.3	11.8	11.4	11.1	10.4	9.8	9.2	8.8	8.3	7.9	7.3	6.7	6.2
4.0	19.3	18.3	17.4	16.6	15.9	15.2	14.6	14.0	13.5	13.0	12.5	12.1	11.7	11.3	10.7	10.1	9.5	9.0	8.6	8.2	7.5	6.9	6.4
4.2	19.4	18.4	17.6	16.8	16.1	15.4	14.8	14.2	13.7	13.2	12.8	12.4	12.0	11.6	10.9	10.3	9.8	9.3	8.9	8.5	7.8	7.2	6.7
4.4	19.5	18.6	17.7	17.0	16.3	15.6	15.0	14.5	14.0	13.5	13.1	12.6	12.3	11.9	11.2	10.6	10.1	9.6	9.1	8.7	8.0	7.4	6.9
4.6	19.6	18.7	17.9	17.2	16.5	15.9	15.3	14.7	14.2	13.8	13.3	12.9	12.5	12.2	11.5	10.9	10.3	9.8	9.4	9.0	8.3	7.7	7.1
4.8	19.8	18.9	18.1	17.4	16.7	16.1	15.5	15.0	14.5	14.0	13.6	13.2	12.8	12.4	11.8	11.2	10.6	10.1	9.7	9.3	8.5	7.9	7.4
5.0	19.9	19.1	18.3	17.6	17.0	16.4	15.8	15.3	14.8	14.3	13.9	13.5	13.1	12.7	12.0	11.4	10.9	10.4	9.9	9.5	8.8	8.1	7.6
5.2	20.1	19.3	18.5	17.8	17.2	16.6	16.0	15.5	15.0	14.6	14.1	13.7	13.3	13.0	12.3	11.7	11.1	10.6	10.2	9.8	9.0	8.4	7.8
5.4	20.3	19.5	18.8	18.1	17.4	16.9	16.3	15.8	15.3	14.8	14.4	14.0	13.6	13.2	12.6	12.0	11.4	10.9	10.4	10.0	9.3	8.6	8.1
5.6	20.5	19.7	19.0	18.3	17.7	17.1	16.6	16.0	15.6	15.1	14.7	14.3	13.9	13.5	12.8	12.2	11.7	11.2	10.7	10.3	9.5	8.9	8.3
5.8	20.7	19.9	19.2	18.6	17.9	17.4	16.8	16.3	15.8	15.4	14.9	14.5	14.1	13.8	13.1	12.5	11.9	11.4	11.0	10.5	9.8	9.1	8.5
6.0	20.9	20.2	19.5	18.8	18.2	17.6	17.1	16.6	16.1	15.6	15.2	14.8	14.4	14.0	13.4	12.8	12.2	11.7	11.2	10.8	10.0	9.3	8.7
6.2	21.2	20.4	19.7	19.1	18.4	17.9	17.3	16.8	16.3	15.9	15.5	15.1	14.7	14.3	13.6	13.0	12.5	11.9	11.5	11.0	10.2	9.6	9.0
6.4	21.4	20.6	20.0	19.3	18.7	18.1	17.6	17.1	16.6	16.2	15.7	15.3	14.9	14.6	13.9	13.3	12.7	12.2	11.7	11.3	10.5	9.8	9.2
6.6	21.6	20.9	20.2	19.6	19.0	18.4	17.9	17.4	16.9	16.4	16.0	15.6	15.2	14.8	14.2	13.5	13.0	12.4	12.0	11.5	10.7	10.0	9.4
6.8	21.9	21.1	20.5	19.8	19.2	18.7	18.1	17.6	17.1	16.7	16.3	15.9	15.5	15.1	14.4	13.8	13.2	12.7	12.2	11.8	10.9	10.2	9.6
7.0	22.1	21.4	20.7	20.1	19.5	18.9	18.4	17.9	17.4	17.0	16.5	16.1	15.7	15.4	14.7	14.1	13.5	12.9	12.5	12.0	11.2	10.5	9.8
7.2	22.3	21.6	21.0	20.3	19.7	19.2	18.6	18.1	17.7	17.2	16.8	16.4	16.0	15.6	14.9	14.3	13.7	13.2	12.7	12.2	11.4	10.7	10.1
7.4	22.6	21.9	21.2	20.6	20.0	19.4	18.9	18.4	17.9	17.5	17.1	16.7	16.3	15.9	15.2	14.6	14.0	13.4	12.9	12.5	11.6	10.9	10.3
7.6	22.8	22.1	21.5	20.8	20.3	19.7	19.2	18.7	18.2	17.8	17.3	16.9	16.5	16.2	15.5	14.8	14.2	13.7	13.2	12.7	11.9	11.1	10.5
7.8	23.1	22.4	21.7	21.1	20.5	20.0	19.4	18.9	18.5	18.0	17.6	17.2	16.8	16.4	15.7	15.1	14.5	13.9	13.4	13.0	12.1	11.4	10.7
8.0	23.3	22.6	22.0	21.4	20.8	20.2	19.7	19.2	18.7	18.3	17.8	17.4	17.0	16.7	16.0	15.3	14.7	14.2	13.7	13.2	12.3	11.6	10.9
8.2	23.6	22.9	22.2	21.6	21.0	20.5	20.0	19.5	19.0	18.5	18.1	17.7	17.3	16.9	16.2	15.6	15.0	14.4	13.9	13.4	12.6	11.8	11.1
8.4	23.8	23.1	22.5	21.9	21.3	20.7	20.2	19.7	19.3	18.8	18.4	18.0	17.6	17.2	16.5	15.8	15.2	14.7	14.2	13.7	12.8	12.0	11.3
8.6	24.1	23.4	22.8	22.1	21.6	21.0	20.5	20.0	19.5	19.1	18.6	18.2	17.8	17.4	16.7	16.1	15.5	14.9	14.4	13.9	13.0	12.2	11.6
8.8	24.3	23.7	23.0	22.4	21.8	21.3	20.7	20.2	19.8	19.3	18.9	18.5	18.1	17.7	17.0	16.3	15.7	15.2	14.6	14.1	13.2	12.5	11.8
9.0	24.6	23.9	23.3	22.7	22.1	21.5	21.0	20.5	20.0	19.6	19.1	18.7	18.3	18.0	17.2	16.6	16.0	15.4	14.9	14.4	13.5	12.7	12.0
9.2	24.8	24.2	23.5	22.9	22.3	21.8	21.3	20.8	20.3	19.8	19.4	19.0	18.6	18.2	17.5	16.8	16.2	15.6	15.1	14.6	13.7	12.9	12.2
9.4	25.1	24.4	23.8	23.2	22.6	22.0	21.5	21.0	20.5	20.1	19.7	19.2	18.8	18.5	17.7	17.1	16.4	15.9	15.3	14.8	13.9	13.1	12.4
9.6	25.4	24.7	24.0	23.4	22.9	22.3	21.8	21.3	20.8	20.3	19.9	19.5	19.1	18.7	18.0	17.3	16.7	16.1	15.6	15.1	14.1	13.3	12.6
9.8	25.6	24.9	24.3	23.7	23.1	22.6	22.0	21.5	21.1	20.6	20.2	19.7	19.3	19.0	18.2	17.6	16.9	16.3	15.8	15.3	14.4	13.5	12.8
10.0	25.9	25.2	24.6	23.9	23.4	22.8	22.3	21.8	21.3	20.9	20.4	20.0	19.6	19.2	18.5	17.8	17.2	16.6	16.0	15.5	14.6	13.8	13.0
10.5	26.5	25.8	25.2	24.6	24.0	23.5	22.9	22.4	22.0	21.5	21.0	20.6	20.2	19.8	19.1	18.4	17.8	17.2	16.6	16.1	15.1	14.3	13.5
11.0	27.1	26.5	25.8	25.2	24.7	24.1	23.6	23.1	22.6	22.1	21.7	21.2	20.8	20.4	19.7	19.0	18.4	17.7	17.2	16.6	15.7	14.8	14.0
11.5	27.8	27.1	26.5	25.9	25.3	24.7	24.2	23.7	23.2	22.7	22.3	21.9	21.5	21.1	20.3	19.6	18.9	18.3	17.7	17.2	16.2	15.3	14.5
12.0	28.4	27.7	27.1	26.5	25.9	25.4	24.8	24.3	23.8	23.4	22.9	22.5	22.1	21.7	20.9	20.2	19.5	18.9	18.3	17.8	16.8	15.9	15.1
12.5	29.0	28.4	27.7	27.1	26.6	26.0	25.5	25.0	24.5	24.0	23.5	23.1	22.7	22.3	21.5	20.8	20.1	19.5	18.9	18.3	17.3	16.4	15.6
13.0	29.7	29.0	28.4	27.8	27.2	26.6	26.1	25.6	25.1	24.6	24.1	23.7	23.3	22.9	22.1	21.3	20.7	20.0	19.4	18.9	17.8	16.9	16.0
13.5	30.3	29.6	29.0	28.4	27.8	27.2	26.7	26.2	25.7	25.2	24.7	24.3	23.9	23.5	22.7	21.9	21.2	20.6	20.0	19.4	18.3	17.4	16.5
14.0	30.9	30.3	29.6	29.0	28.4	27.9	27.3	26.8	26.3	25.8	25.3	24.9	24.5	24.0	23.2	22.5	21.8	21.1	20.5	19.9	18.9	17.9	17.0
14.5	31.6	30.9	30.3	29.6	29.0	28.5	27.9	27.4	26.9	26.4	25.9	25.5	25.1	24.6	23.8	23.1	22.4	21.7	21.1	20.5	19.4	18.4	17.5
15.0	32.2	31.5	30.9	30.3	29.7	29.1	28.5	28.0	27.5	27.0	26.5	26.1	25.6	25.2	24.4	23.6	22.9	22.2	21.6	21.0	19.9	18.9	18.0
15.5	32.8	32.1	31.5	30.9	30.3	29.7	29.1	28.6	28.1	27.6	27.1	26.7	26.2	25.8	25.0	24.2	23.5	22.8	22.2	21.5	20.4	19.4	18.5
16.0	33.4	32.7	32.1	31.5	30.9	30.3	29.8	29.2	28.7	28.2	27.7	27.3	26.8	26.4	25.5	24.8	24.0	23.3	22.7	22.1	20.9	19.9	19.0
16.5	34.0	33.4	32.7	32.1	31.5	30.9	30.3	29.8	29.3	28.8	28.3	27.8	27.4	26.9	26.1	25.3	24.6	23.9	23.2	22.6	21.4	20.4	19.5
17.0	34.7	34.0	33.3	32.7	32.1	31.5	30.9	30.4	29.9	29.4	28.9	28.4	28.0	27.5	26.7	25.9	25.1	24.4	23.8	23.1	22.0	20.9	19.9
17.5	35.3	34.6	33.9	33.3	32.7	32.1	31.5	31.0	30.5	30.0	29.5	29.0	28.5	28.1	27.2	26.4	25.7	25.0	24.3	23.6	22.5	21.4	20.4
18.0	35.9	35.2	34.5	33.9	33.3	32.7	32.1	31.6	31.1	30.5	30.0	29.6	29.1	28.6	27.8	27.0	26.2	25.5	24.8	24.2	23.0	21.9	20.9
18.5	36.5	35.8	35.1	34.5	33.9	33.3	32.7	32.2	31.6	31.1	30.6	30.1	29.7	29.2	28.3	27.5	26.8	26.0	25.3	24.7	23.5	22.4	21.4
19.0	37.1	36.4	35.7	35.1	34.5	33.9	33.3	32.8	32.2	31.7	31.2	30.7	30.2	29.8	28.9	28.1	27.3	26.5	25.8	25.2	24.0	22.8	21.8
19.5	37.7	37.0	36.3	35.7	35.1	34.5	33.9	33.3	32.8	32.3	31.8	31.3	30.8	30.3	29.4	28.6	27.8	27.1	26.4	25.7	24.5	23.3	22.3
20.0	38.3	37.6	36.9	36.3	35.7	35.1	34.5	33.9	33.4	32.8	32.3	31.8	31.3	30.9	30.0	29.1	28.4	27.6	26.9	26.2	24.9	23.8	22.8
21.0	39.5	38.8	38.1	37.4	36.8	36.2	35.6	35.1	34.5	34.0	33.4	32.9	32.5	32.0	31.1	30.2	29.4	28.6	27.9	27.2	25.9	24.8	23.7
22.0	40.7	40.0	39.3	38.6	38.0	37.4	36.8	36.2	35.6	35.1	34.6	34.1	33.6	33.1	32.2	31.3	30.5	29.7	28.9	28.2	26.9	25.7	24.6

* The Basic Energy Use obtained from this table is to be used in Equation 6-1.

Table 6-7B– Basic Energy Use (BEU) - Storage Electric Heater [no interpolation]*

Adj Recovery Load	Energy Factor																						
	0.77	0.78	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99
3.0	22.4	21.1	20.0	19.0	18.1	17.2	16.5	15.8	15.2	14.6	14.0	13.5	13.0	12.6	12.2	11.8	11.5	11.1	10.8	10.5	10.2	9.9	9.7
3.2	23.0	21.8	20.7	19.7	18.8	18.0	17.2	16.5	15.9	15.3	14.7	14.2	13.8	13.3	12.9	12.5	12.1	11.8	11.5	11.1	10.8	10.6	10.3
3.4	23.6	22.4	21.3	20.4	19.5	18.7	17.9	17.2	16.6	16.0	15.4	14.9	14.4	14.0	13.6	13.2	12.8	12.4	12.1	11.8	11.5	11.2	10.9
3.6	24.2	23.1	22.0	21.1	20.2	19.4	18.6	17.9	17.3	16.7	16.1	15.6	15.1	14.7	14.2	13.8	13.5	13.1	12.7	12.4	12.1	11.8	11.5
3.8	24.8	23.7	22.7	21.7	20.9	20.1	19.3	18.6	18.0	17.4	16.8	16.3	15.8	15.4	14.9	14.5	14.1	13.7	13.4	13.1	12.7	12.4	12.1
4.0	25.5	24.4	23.3	22.4	21.6	20.8	20.0	19.3	18.7	18.1	17.5	17.0	16.5	16.0	15.6	15.2	14.8	14.4	14.0	13.7	13.4	13.1	12.8
4.2	26.1	25.0	24.0	23.1	22.2	21.4	20.7	20.0	19.4	18.8	18.2	17.7	17.2	16.7	16.3	15.8	15.4	15.0	14.7	14.3	14.0	13.7	13.4
4.4	26.7	25.6	24.7	23.8	22.9	22.1	21.4	20.7	20.1	19.5	18.9	18.4	17.8	17.4	16.9	16.5	16.1	15.7	15.3	15.0	14.6	14.3	14.0
4.6	27.3	26.3	25.3	24.4	23.6	22.8	22.1	21.4	20.7	20.1	19.6	19.0	18.5	18.0	17.6	17.1	16.7	16.3	15.9	15.6	15.2	14.9	14.6
4.8	28.0	26.9	26.0	25.1	24.3	23.5	22.7	22.1	21.4	20.8	20.2	19.7	19.2	18.7	18.2	17.8	17.4	17.0	16.6	16.2	15.9	15.5	15.2
5.0	28.6	27.6	26.6	25.7	24.9	24.1	23.4	22.7	22.1	21.5	20.9	20.4	19.8	19.3	18.9	18.4	18.0	17.6	17.2	16.8	16.5	16.1	15.8
5.2	29.2	28.2	27.3	26.4	25.6	24.8	24.1	23.4	22.7	22.1	21.6	21.0	20.5	20.0	19.5	19.1	18.6	18.2	17.8	17.5	17.1	16.7	16.4
5.4	29.8	28.8	27.9	27.0	26.2	25.5	24.7	24.1	23.4	22.8	22.2	21.7	21.1	20.6	20.2	19.7	19.3	18.9	18.5	18.1	17.7	17.4	17.0
5.6	30.4	29.5	28.5	27.7	26.9	26.1	25.4	24.7	24.1	23.5	22.9	22.3	21.8	21.3	20.8	20.3	19.9	19.5	19.1	18.7	18.3	18.0	17.6
5.8	31.0	30.1	29.2	28.3	27.5	26.8	26.0	25.4	24.7	24.1	23.5	23.0	22.4	21.9	21.4	21.0	20.5	20.1	19.7	19.3	18.9	18.6	18.2
6.0	31.6	30.7	29.8	29.0	28.2	27.4	26.7	26.0	25.4	24.7	24.2	23.6	23.1	22.6	22.1	21.6	21.2	20.7	20.3	19.9	19.5	19.2	18.8
6.2	32.3	31.3	30.4	29.6	28.8	28.0	27.3	26.7	26.0	25.4	24.8	24.2	23.7	23.2	22.7	22.2	21.8	21.4	20.9	20.5	20.2	19.8	19.4
6.4	32.9	31.9	31.1	30.2	29.4	28.7	28.0	27.3	26.6	26.0	25.4	24.9	24.3	23.8	23.3	22.9	22.4	22.0	21.6	21.2	20.8	20.4	20.0
6.6	33.5	32.5	31.7	30.8	30.1	29.3	28.6	27.9	27.3	26.7	26.1	25.5	25.0	24.5	24.0	23.5	23.0	22.6	22.2	21.8	21.4	21.0	20.6
6.8	34.1	33.2	32.3	31.5	30.7	29.9	29.2	28.6	27.9	27.3	26.7	26.2	25.6	25.1	24.6	24.1	23.7	23.2	22.8	22.4	22.0	21.6	21.2
7.0	34.7	33.8	32.9	32.1	31.3	30.6	29.9	29.2	28.6	27.9	27.3	26.8	26.2	25.7	25.2	24.7	24.3	23.8	23.4	23.0	22.6	22.2	21.8
7.2	35.3	34.4	33.5	32.7	31.9	31.2	30.5	29.8	29.2	28.6	28.0	27.4	26.9	26.3	25.8	25.4	24.9	24.4	24.0	23.6	23.2	22.8	22.4
7.4	35.9	35.0	34.1	33.3	32.6	31.8	31.1	30.5	29.8	29.2	28.6	28.0	27.5	27.0	26.5	26.0	25.5	25.1	24.6	24.2	23.8	23.4	23.0
7.6	36.5	35.6	34.7	33.9	33.2	32.4	31.7	31.1	30.4	29.8	29.2	28.7	28.1	27.6	27.1	26.6	26.1	25.7	25.2	24.8	24.4	24.0	23.6
7.8	37.0	36.2	35.3	34.5	33.8	33.1	32.4	31.7	31.1	30.4	29.8	29.3	28.7	28.2	27.7	27.2	26.7	26.3	25.8	25.4	25.0	24.6	24.2
8.0	37.6	36.8	35.9	35.2	34.4	33.7	33.0	32.3	31.7	31.1	30.5	29.9	29.4	28.8	28.3	27.8	27.3	26.9	26.4	26.0	25.6	25.2	24.8
8.2	38.2	37.4	36.5	35.8	35.0	34.3	33.6	32.9	32.3	31.7	31.1	30.5	30.0	29.4	28.9	28.4	28.0	27.5	27.0	26.6	26.2	25.8	25.4
8.4	38.8	37.9	37.1	36.4	35.6	34.9	34.2	33.5	32.9	32.3	31.7	31.1	30.6	30.0	29.5	29.0	28.6	28.1	27.7	27.2	26.8	26.4	26.0
8.6	39.4	38.5	37.7	37.0	36.2	35.5	34.8	34.2	33.5	32.9	32.3	31.7	31.2	30.7	30.1	29.7	29.2	28.7	28.3	27.8	27.4	27.0	26.6
8.8	40.0	39.1	38.3	37.6	36.8	36.1	35.4	34.8	34.1	33.5	32.9	32.4	31.8	31.3	30.8	30.3	29.8	29.3	28.9	28.4	28.0	27.6	27.2
9.0	40.5	39.7	38.9	38.1	37.4	36.7	36.0	35.4	34.7	34.1	33.5	33.0	32.4	31.9	31.4	30.9	30.4	29.9	29.5	29.0	28.6	28.2	27.8
9.2	41.1	40.3	39.5	38.7	38.0	37.3	36.6	36.0	35.3	34.7	34.1	33.6	33.0	32.5	32.0	31.5	31.0	30.5	30.1	29.6	29.2	28.8	28.4
9.4	41.7	40.9	40.1	39.3	38.6	37.9	37.2	36.6	35.9	35.3	34.7	34.2	33.6	33.1	32.6	32.1	31.6	31.1	30.7	30.2	29.8	29.4	29.0
9.6	42.3	41.4	40.7	39.9	39.2	38.5	37.8	37.2	36.5	35.9	35.3	34.8	34.2	33.7	33.2	32.7	32.2	31.7	31.3	30.8	30.4	30.0	29.5
9.8	42.8	42.0	41.2	40.5	39.8	39.1	38.4	37.8	37.1	36.5	35.9	35.4	34.8	34.3	33.8	33.3	32.8	32.3	31.9	31.4	31.0	30.5	30.1
10.0	43.4	42.6	41.8	41.1	40.4	39.7	39.0	38.4	37.7	37.1	36.5	36.0	35.4	34.9	34.4	33.9	33.4	32.9	32.4	32.0	31.6	31.1	30.7
10.5	44.8	44.0	43.3	42.5	41.8	41.1	40.5	39.8	39.2	38.6	38.0	37.5	36.9	36.4	35.9	35.4	34.9	34.4	33.9	33.5	33.0	32.6	32.2
11.0	46.2	45.4	44.7	44.0	43.3	42.6	41.9	41.3	40.7	40.1	39.5	39.0	38.4	37.9	37.4	36.8	36.4	35.9	35.4	35.0	34.5	34.1	33.7
11.5	47.6	46.8	46.1	45.4	44.7	44.0	43.4	42.8	42.2	41.6	41.0	40.4	39.9	39.3	38.8	38.3	37.8	37.4	36.9	36.4	36.0	35.6	35.1
12.0	49.0	48.2	47.5	46.8	46.1	45.5	44.8	44.2	43.6	43.0	42.5	41.9	41.3	40.8	40.3	39.8	39.3	38.8	38.4	37.9	37.5	37.0	36.6
12.5	50.3	49.6	48.9	48.2	47.6	46.9	46.3	45.7	45.1	44.5	43.9	43.4	42.8	42.3	41.8	41.3	40.8	40.3	39.8	39.4	38.9	38.5	38.1
13.0	51.7	51.0	50.3	49.6	49.0	48.3	47.7	47.1	46.5	45.9	45.4	44.8	44.3	43.7	43.2	42.7	42.2	41.8	41.3	40.8	40.4	40.0	39.5
13.5	53.1	52.4	51.7	51.0	50.4	49.7	49.1	48.5	47.9	47.3	46.8	46.2	45.7	45.2	44.7	44.2	43.7	43.2	42.8	42.3	41.8	41.4	41.0
14.0	54.4	53.7	53.0	52.4	51.7	51.1	50.5	49.9	49.3	48.8	48.2	47.7	47.2	46.6	46.1	45.6	45.1	44.7	44.2	43.8	43.3	42.9	42.4
14.5	55.7	55.1	54.4	53.8	53.1	52.5	51.9	51.3	50.8	50.2	49.6	49.1	48.6	48.1	47.6	47.1	46.6	46.1	45.7	45.2	44.8	44.3	43.9
15.0	57.1	56.4	55.7	55.1	54.5	53.9	53.3	52.7	52.2	51.6	51.1	50.5	50.0	49.5	49.0	48.5	48.0	47.6	47.1	46.7	46.2	45.8	45.3
15.5	58.4	57.7	57.1	56.5	55.9	55.3	54.7	54.1	53.6	53.0	52.5	52.0	51.4	50.9	50.4	50.0	49.5	49.0	48.5	48.1	47.7	47.2	46.8
16.0	59.7	59.1	58.4	57.8	57.2	56.6	56.1	55.5	54.9	54.4	53.9	53.4	52.9	52.4	51.9	51.4	50.9	50.4	50.0	49.5	49.1	48.7	48.2
16.5	61.0	60.4	59.8	59.2	58.6	58.0	57.4	56.9	56.3	55.8	55.3	54.8	54.3	53.8	53.3	52.8	52.3	51.9	51.4	51.0	50.5	50.1	49.7
17.0	62.3	61.7	61.1	60.5	59.9	59.4	58.8	58.3	57.7	57.2	56.7	56.2	55.7	55.2	54.7	54.2	53.8	53.3	52.9	52.4	52.0	51.6	51.1
17.5	63.6	63.0	62.4	61.8	61.3	60.7	60.2	59.6	59.1	58.6	58.1	57.6	57.1	56.6	56.1	55.6	55.2	54.7	54.3	53.9	53.4	53.0	52.6
18.0	64.9	64.3	63.7	63.1	62.6	62.0	61.5	61.0	60.5	59.9	59.4	59.0	58.5	58.0	57.5	57.1	56.6	56.2	55.7	55.3	54.9	54.4	54.0
18.5	66.1	65.6	65.0	64.5	63.9	63.4	62.8	62.3	61.8	61.3	60.8	60.3	59.9	59.4	58.9	58.5	58.0	57.6	57.1	56.7	56.3	55.9	55.5
19.0	67.4	66.9	66.3	65.8	65.2	64.7	64.2	63.7	63.2	62.7	62.2	61.7	61.2	60.8	60.3	59.9	59.4	59.0	58.6	58.1	57.7	57.3	56.9
19.5	68.7	68.1	67.6	67.1	66.5	66.0	65.5	65.0	64.5	64.0	63.6	63.1	62.6	62.2	61.7	61.3	60.8	60.4	60.0	59.6	59.2	58.7	58.3
20.0	70.0	69.4	68.9	68.4	67.9	67.3	66.8	66.4	65.9	65.4	64.9	64.5	64.0	63.6	63.1	62.7	62.3	61.8	61.4	61.0	60.6	60.2	59.8
21.0	72.5	71.9	71.4	70.9	70.5	70.0	69.5	69.0	68.6	68.1	67.6	67.2	66.8	66.3	65.9	65.5	65.1	64.6	64.2	63.8	63.4	63.0	62.7
22.0	74.9	74.5	74.0	73.5	73.0	72.6	72.1	71.7	71.2	70.8	70.3	69.9	69.5	69.1	68.7	68.2	67.8	67.4	67.1	66.7	66.3	65.9	65.5

* The Basic Energy Use obtained from this table is to be used in Equation 6-1.

Table 6-7C– Basic Energy Use (BEU) - Storage Heat Pump Heater [no interpolation]*

Adjusted Recovery Load	Energy Factor																				
	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8
6.0	14.1	13.5	13.0	12.6	12.1	11.7	11.3	11.0	10.6	10.3	10.0	9.7	9.5	9.2	9.0	8.7	8.5	8.3	8.1	7.9	7.8
6.2	14.4	13.8	13.3	12.8	12.3	11.9	11.5	11.1	10.8	10.5	10.2	9.9	9.6	9.3	9.1	8.9	8.7	8.4	8.2	8.0	7.9
6.4	14.7	14.1	13.5	13.0	12.5	12.1	11.7	11.3	11.0	10.6	10.3	10.0	9.7	9.5	9.2	9.0	8.8	8.6	8.3	8.2	8.0
6.6	14.9	14.3	13.8	13.2	12.8	12.3	11.9	11.5	11.1	10.8	10.5	10.2	9.9	9.6	9.4	9.1	8.9	8.7	8.5	8.3	8.1
6.8	15.2	14.6	14.0	13.5	13.0	12.5	12.1	11.7	11.3	11.0	10.6	10.3	10.0	9.8	9.5	9.3	9.0	8.8	8.6	8.4	8.2
7.0	15.5	14.8	14.2	13.7	13.2	12.7	12.3	11.9	11.5	11.1	10.8	10.5	10.2	9.9	9.6	9.4	9.1	8.9	8.7	8.5	8.3
7.2	15.8	15.1	14.5	13.9	13.4	12.9	12.5	12.1	11.7	11.3	11.0	10.6	10.3	10.0	9.8	9.5	9.3	9.0	8.8	8.6	8.4
7.4	16.0	15.4	14.7	14.2	13.6	13.1	12.7	12.2	11.8	11.5	11.1	10.8	10.5	10.2	9.9	9.6	9.4	9.1	8.9	8.7	8.5
7.6	16.3	15.6	15.0	14.4	13.8	13.3	12.9	12.4	12.0	11.6	11.3	10.9	10.6	10.3	10.0	9.8	9.5	9.3	9.0	8.8	8.6
7.8	16.6	15.9	15.2	14.6	14.0	13.5	13.0	12.6	12.2	11.8	11.4	11.1	10.8	10.5	10.2	9.9	9.6	9.4	9.2	8.9	8.7
8.0	16.8	16.1	15.4	14.8	14.3	13.7	13.2	12.8	12.4	12.0	11.6	11.2	10.9	10.6	10.3	10.0	9.8	9.5	9.3	9.0	8.8
8.2	17.1	16.4	15.7	15.0	14.5	13.9	13.4	13.0	12.5	12.1	11.7	11.4	11.0	10.7	10.4	10.1	9.9	9.6	9.4	9.2	8.9
8.4	17.4	16.6	15.9	15.3	14.7	14.1	13.6	13.1	12.7	12.3	11.9	11.5	11.2	10.9	10.6	10.3	10.0	9.7	9.5	9.3	9.0
8.6	17.7	16.9	16.1	15.5	14.9	14.3	13.8	13.3	12.9	12.4	12.0	11.7	11.3	11.0	10.7	10.4	10.1	9.9	9.6	9.4	9.1
8.8	17.9	17.1	16.4	15.7	15.1	14.5	14.0	13.5	13.0	12.6	12.2	11.8	11.5	11.1	10.8	10.5	10.2	10.0	9.7	9.5	9.3
9.0	18.2	17.4	16.6	15.9	15.3	14.7	14.2	13.7	13.2	12.8	12.4	12.0	11.6	11.3	11.0	10.7	10.4	10.1	9.8	9.6	9.4
9.2	18.4	17.6	16.8	16.1	15.5	14.9	14.4	13.9	13.4	12.9	12.5	12.1	11.8	11.4	11.1	10.8	10.5	10.2	10.0	9.7	9.5
9.4	18.7	17.9	17.1	16.4	15.7	15.1	14.5	14.0	13.5	13.1	12.7	12.3	11.9	11.5	11.3	10.9	10.6	10.3	10.1	9.8	9.6
9.6	19.0	18.1	17.3	16.6	15.9	15.3	14.7	14.2	13.7	13.3	12.8	12.4	12.0	11.7	11.4	11.0	10.7	10.5	10.2	9.9	9.7
9.8	19.2	18.3	17.5	16.8	16.1	15.5	14.9	14.4	13.9	13.4	13.0	12.6	12.2	11.8	11.5	11.2	10.9	10.6	10.3	10.0	9.8
10.0	19.5	18.6	17.8	17.0	16.3	15.7	15.1	14.6	14.0	13.6	13.1	12.7	12.3	12.0	11.7	11.3	11.0	10.7	10.4	10.1	9.9
10.5	20.1	19.2	18.3	17.6	16.8	16.2	15.6	15.0	14.5	14.0	13.5	13.1	12.7	12.3	11.9	11.6	11.3	11.0	10.7	10.4	10.2
11.0	20.8	19.8	18.9	18.1	17.3	16.7	16.0	15.4	14.9	14.4	13.9	13.4	13.0	12.6	12.3	11.9	11.6	11.3	11.0	10.7	10.4
11.5	21.4	20.4	19.5	18.6	17.8	17.1	16.5	15.9	15.3	14.8	14.3	13.8	13.4	13.0	12.6	12.2	11.9	11.6	11.3	11.0	10.7
12.0	22.1	21.0	20.0	19.1	18.3	17.6	16.9	16.3	15.7	15.1	14.6	14.2	13.7	13.3	12.9	12.5	12.2	11.9	11.5	11.2	11.0
12.5	22.7	21.6	20.6	19.7	18.8	18.1	17.4	16.7	16.1	15.5	15.0	14.5	14.1	13.6	13.2	12.8	12.5	12.1	11.8	11.5	11.2
13.0	23.3	22.2	21.1	20.2	19.3	18.5	17.8	17.1	16.5	15.9	15.4	14.9	14.4	14.0	13.5	13.1	12.8	12.4	12.1	11.8	11.5
13.5	23.9	22.7	21.7	20.7	19.8	19.0	18.2	17.6	16.9	16.3	15.8	15.2	14.7	14.3	13.9	13.5	13.1	12.7	12.4	12.0	11.7
14.0	24.5	23.3	22.2	21.2	20.3	19.5	18.7	18.0	17.3	16.7	16.1	15.6	15.1	14.6	14.2	13.8	13.4	13.0	12.6	12.3	12.0
14.5	25.2	23.9	22.8	21.7	20.8	19.9	19.1	18.4	17.7	17.1	16.5	15.9	15.4	14.9	14.5	14.1	13.7	13.3	12.9	12.6	12.3
15.0	25.8	24.5	23.3	22.2	21.3	20.4	19.6	18.8	18.1	17.4	16.8	16.3	15.8	15.3	14.8	14.4	13.9	13.6	13.2	12.8	12.5
15.5	26.4	25.0	23.8	22.7	21.7	20.8	20.0	19.2	18.5	17.8	17.2	16.6	16.1	15.6	15.1	14.7	14.2	13.8	13.5	13.1	12.8
16.0	27.0	25.6	24.4	23.2	22.2	21.3	20.4	19.6	18.9	18.2	17.6	17.0	16.4	15.9	15.4	15.0	14.5	14.1	13.7	13.4	13.0
16.5	27.6	26.2	24.9	23.7	22.7	21.7	20.8	20.0	19.3	18.6	17.9	17.3	16.7	16.2	15.7	15.2	14.8	14.4	14.0	13.6	13.3
17.0	28.2	26.7	25.4	24.2	23.2	22.2	21.3	20.4	19.7	18.9	18.3	17.7	17.1	16.5	16.0	15.5	15.1	14.7	14.3	13.9	13.5
17.5	28.8	27.3	25.9	24.7	23.6	22.6	21.7	20.8	20.0	19.3	18.6	18.0	17.4	16.8	16.3	15.8	15.4	14.9	14.5	14.1	13.8
18.0	29.4	27.8	26.5	25.2	24.1	23.1	22.1	21.2	20.4	19.7	19.0	18.3	17.7	17.2	16.6	16.1	15.7	15.2	14.8	14.4	14.0
18.5	29.9	28.4	27.0	25.7	24.5	23.5	22.5	21.6	20.8	20.0	19.3	18.7	18.0	17.5	16.9	16.4	15.9	15.5	15.1	14.7	14.3
19.0	30.5	28.9	27.5	26.2	25.0	23.9	23.3	22.0	21.2	20.4	19.7	19.0	18.4	17.8	17.2	16.7	16.2	15.8	15.3	14.9	14.5
19.5	31.1	29.5	28.0	26.7	25.5	24.4	23.3	22.4	21.6	20.8	20.0	19.3	18.7	18.1	17.5	17.0	16.5	16.0	15.6	15.2	14.8
20.0	31.7	30.0	28.5	27.2	25.9	24.8	23.8	22.8	21.9	21.1	20.4	19.7	19.0	18.4	17.8	17.3	16.8	16.3	15.8	15.4	15.0
21.0	32.8	31.1	29.5	28.1	26.8	25.7	24.6	23.6	22.7	21.8	21.1	20.3	19.6	19.0	18.4	17.8	17.3	16.8	16.4	15.9	15.5
22.0	34.0	32.2	30.5	29.1	27.7	26.5	25.4	24.4	23.4	22.5	21.7	21.0	20.3	19.6	19.0	18.4	17.9	17.4	16.9	16.4	16.0

* The Basic Energy Use obtained from this table is to be used in Equation 6-1.

Table 6-7D– Basic Energy Use (BEU) - Instantaneous Gas or Electric Heaters [no interpolation]

	Pilot Energy (Btu/Hour)												
Recovery Energy	200	250	300	350	400	450	500	550	600	650	700	750	800
3.0	4.8	5.2	5.6	6.1	6.5	6.9	7.4	7.8	8.3	8.7	9.1	9.6	10.0
3.2	5.0	5.4	5.8	6.3	6.7	7.1	7.6	8.0	8.5	8.9	9.3	9.8	10.2
3.4	5.2	5.6	6.0	6.5	6.9	7.3	7.8	8.2	8.7	9.1	9.5	10.0	10.4
3.6	5.4	5.8	6.2	6.7	7.1	7.5	8.0	8.4	8.9	9.3	9.7	10.2	10.6
3.8	5.6	6.0	6.4	6.9	7.3	7.7	8.2	8.6	9.1	9.5	9.9	10.4	10.8
4.0	5.8	6.2	6.6	7.1	7.5	7.9	8.4	8.8	9.3	9.7	10.1	10.6	11.0
4.2	6.0	6.4	6.8	7.3	7.7	8.1	8.6	9.0	9.5	9.9	10.3	10.8	11.2
4.4	6.2	6.6	7.0	7.5	7.9	8.3	8.8	9.2	9.7	10.1	10.5	11.0	11.4
4.6	6.4	6.8	7.2	7.7	8.1	8.5	9.0	9.4	9.9	10.3	10.7	11.2	11.6
4.8	6.6	7.0	7.4	7.9	8.3	8.7	9.2	9.6	10.1	10.5	10.9	11.4	11.8
5.0	6.8	7.2	7.6	8.1	8.5	8.9	9.4	9.8	10.3	10.7	11.1	11.6	12.0
5.2	7.0	7.4	7.8	8.3	8.7	9.1	9.6	10.0	10.5	10.9	11.3	11.8	12.2
5.4	7.2	7.6	8.0	8.5	8.9	9.3	9.8	10.2	10.7	11.1	11.5	12.0	12.4
5.6	7.4	7.8	8.2	8.7	9.1	9.5	10.0	10.4	10.9	11.3	11.7	12.2	12.6
5.8	7.6	8.0	8.4	8.9	9.3	9.7	10.2	10.6	11.1	11.5	11.9	12.4	12.8
6.0	7.8	8.2	8.6	9.1	9.5	9.9	10.4	10.8	11.3	11.7	12.1	12.6	13.0
6.2	8.0	8.4	8.8	9.3	9.7	10.1	10.6	11.0	11.5	11.9	12.3	12.8	13.2
6.4	8.2	8.6	9.0	9.5	9.9	10.3	10.8	11.2	11.7	12.1	12.5	13.0	13.4
6.6	8.4	8.8	9.2	9.7	10.1	10.5	11.0	11.4	11.9	12.3	12.7	13.2	13.6
6.8	8.6	9.0	9.4	9.9	10.3	10.7	11.2	11.6	12.1	12.5	12.9	13.4	13.8
7.0	8.8	9.2	9.6	10.1	10.5	10.9	11.4	11.8	12.3	12.7	13.1	13.6	14.0
7.2	9.0	9.4	9.8	10.3	10.7	11.1	11.6	12.0	12.5	12.9	13.3	13.8	14.2
7.4	9.2	9.6	10.0	10.5	10.9	11.3	11.8	12.2	12.7	13.1	13.5	14.0	14.4
7.6	9.4	9.8	10.2	10.7	11.1	11.5	12.0	12.4	12.9	13.3	13.7	14.2	14.6
7.8	9.6	10.0	10.4	10.9	11.3	11.7	12.2	12.6	13.1	13.5	13.9	14.4	14.8
8.0	9.8	10.2	10.6	11.1	11.5	11.9	12.4	12.8	13.3	13.7	14.1	14.6	15.0
8.2	10.0	10.4	10.8	11.3	11.7	12.1	12.6	13.0	13.5	13.9	14.3	14.8	15.2
8.4	10.2	10.6	11.0	11.5	11.9	12.3	12.8	13.2	13.7	14.1	14.5	15.0	15.4
8.6	10.4	10.8	11.2	11.7	12.1	12.5	13.0	13.4	13.9	14.3	14.7	15.2	15.6
8.8	10.6	11.0	11.4	11.9	12.3	12.7	13.2	13.6	14.1	14.5	14.9	15.4	15.8
9.0	10.8	11.2	11.6	12.1	12.5	12.9	13.4	13.8	14.3	14.7	15.1	15.6	16.0
9.2	11.0	11.4	11.8	12.3	12.7	13.1	13.6	14.0	14.5	14.9	15.3	15.8	16.2
9.4	11.2	11.6	12.0	12.5	12.9	13.3	13.8	14.2	14.7	15.1	15.5	16.0	16.4
9.6	11.4	11.8	12.2	12.7	13.1	13.5	14.0	14.4	14.9	15.3	15.7	16.2	16.6
9.8	11.6	12.0	12.4	12.9	13.3	13.7	14.2	14.6	15.1	15.5	15.9	16.4	16.8
10.0	11.8	12.2	12.6	13.1	13.5	13.9	14.4	14.8	15.3	15.7	16.1	16.6	17.0
10.2	12.0	12.4	12.8	13.3	13.7	14.1	14.6	15.0	15.5	15.9	16.3	16.8	17.2
10.4	12.2	12.6	13.0	13.5	13.9	14.3	14.8	15.2	15.7	16.1	16.5	17.0	17.4
10.6	12.4	12.8	13.2	13.7	14.1	14.5	15.0	15.4	15.9	16.3	16.7	17.2	17.6
10.8	12.6	13.0	13.4	13.9	14.3	14.7	15.2	15.6	16.1	16.5	16.9	17.4	17.8
11.0	12.8	13.2	13.6	14.1	14.5	14.9	15.4	15.8	16.3	16.7	17.1	17.6	18.0
11.5	13.3	13.7	14.1	14.6	15.0	15.4	15.9	16.3	16.8	17.2	17.6	18.1	18.5
12.0	13.8	14.2	14.6	15.1	15.5	15.9	16.4	16.8	17.3	17.7	18.1	18.6	19.0
12.5	14.3	14.7	15.1	15.6	16.0	16.4	16.9	17.3	17.8	18.2	18.6	19.1	19.5
13.0	14.8	15.2	15.6	16.1	16.5	16.9	17.4	17.8	18.3	18.7	19.1	19.6	20.0
13.5	15.3	15.7	16.1	16.6	17.0	17.4	17.9	18.3	18.8	19.2	19.6	20.1	20.5
14.0	15.8	16.2	16.6	17.1	17.5	17.9	18.4	18.8	19.3	19.7	20.1	20.6	21.0
14.5	16.3	16.7	17.1	17.6	18.0	18.4	18.9	19.3	19.8	20.2	20.6	21.1	21.5
15.0	16.8	17.2	17.6	18.1	18.5	18.9	19.4	19.8	20.3	20.7	21.1	21.6	22.0
15.5	17.3	17.7	18.1	18.6	19.0	19.4	19.9	20.3	20.8	21.2	21.6	22.1	22.5
16.0	17.8	18.2	18.6	19.1	19.5	19.9	20.4	20.8	21.3	21.7	22.1	22.6	23.0
16.5	18.3	18.7	19.1	19.6	20.0	20.4	20.9	21.3	21.8	22.2	22.6	23.1	23.5
17.0	18.8	19.2	19.6	20.1	20.5	20.9	21.4	21.8	22.3	22.7	23.1	23.6	24.0
17.5	19.3	19.7	20.1	20.6	21.0	21.4	21.9	22.3	22.8	23.2	23.6	24.1	24.5
18.0	19.8	20.2	20.6	21.1	21.5	21.9	22.4	22.8	23.3	23.7	24.1	24.6	25.0
18.5	20.3	20.7	21.1	21.6	22.0	22.4	22.9	23.3	23.8	24.2	24.6	25.1	25.5
19.0	20.8	21.2	21.6	22.1	22.5	22.9	23.4	23.8	24.3	24.7	25.1	25.6	26.0

Basic Energy Use *(Table 6-7a, 6-7b, or 6-7c)*	x	Climate Zone Factor *(Table 6-10)*	=	*Basic Energy Use to Line 2a, DHW-1*

Instructions for Instantaneous Gas Water Heaters:

1. Calculate:__________________ /__________________________ = _____________________

Adjusted Recovery Load   Recovery Efficiency (fraction)   Recovery Energy

(From line 1e, DHW 1)

2. Find Basic Energy Use from table using Recovery Energy (Step 1) and Pilot Btu/hr (DHW-1, line F)

Use nearest table values. At mid-point use higher value. **Do not interpolate.**

3. Enter Basic Energy Use in Line 2a of DHW-1

Instructions for Instantaneous Electric Water Heaters:

. Calculate:[_________________] / _______________________ x 3 = ___________________

Adjusted Recovery Load (from line 1e, DHW-1)   Energy Factor (from line D, DHW-1)   Basic Energy Use (to line 2a, DHW-1)

2. Enter Basic Energy Use on Line 2a of Worksheet DHW-1.

Note: For instantaneous electric water heaters, Energy Factor equals Recovery Efficiency.

Table 6-7E– Jacket Loss (Indirect Gas)

Tank Volume (Gallons)	Storage Tank Insulation R-value												
	12	13	14	15	16	17	18	20	22	24	26	28	30
0-19	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8
20-29	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.1	1.0	1.0	1.0	0.9	0.9
30-39	1.7	1.6	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.1	1.0	1.0
40-49	1.8	1.7	1.7	1.6	1.5	1.5	1.4	1.3	1.3	1.2	1.1	1.1	1.1
50-59	2.0	1.9	1.8	1.7	1.6	1.6	1.5	1.4	1.3	1.3	1.2	1.2	1.1
60-69	2.2	2.0	1.9	1.8	1.8	1.7	1.6	1.5	1.4	1.4	1.3	1.2	1.2
70-79	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.3	1.3
80-89	2.5	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.3
90-99	2.6	2.4	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4
100-119	2.8	2.6	2.5	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4
120-139	3.0	2.8	2.7	2.5	2.4	2.3	2.2	2.0	1.9	1.8	1.7	1.6	1.5
140-159	3.3	3.1	2.9	2.7	2.6	2.5	2.4	2.2	2.0	1.9	1.8	1.7	1.6
160-179	3.5	3.3	3.1	2.9	2.7	2.6	2.5	2.3	2.1	2.0	1.9	1.8	1.7
180-199	3.7	3.4	3.2	3.1	2.9	2.8	2.6	2.4	2.3	2.1	2.0	1.9	1.8
200-249	4.0	3.8	3.5	3.3	3.2	3.0	2.9	2.6	2.4	2.3	2.2	2.0	1.9
250-299	4.5	4.2	3.9	3.7	3.5	3.3	3.2	2.9	2.7	2.5	2.4	2.2	2.1
300-349	4.9	4.6	4.3	4.1	3.8	3.6	3.5	3.2	2.9	2.7	2.6	2.4	2.3
350-399	5.3	5.0	4.7	4.4	4.1	3.9	3.7	3.4	3.2	2.9	2.8	2.6	2.5
400-449	5.7	5.3	5.0	4.7	4.4	4.2	4.0	3.7	3.4	3.1	2.9	2.8	2.6
450-499	6.1	5.7	5.3	5.0	4.7	4.5	4.3	3.9	3.6	3.3	3.1	2.9	2.8
500-1000	8.0	7.4	6.9	6.5	6.1	5.8	5.5	5.0	4.6	4.3	4.0	3.7	3.5
1000	9.5	8.8	8.2	7.7	7.2	6.8	6.5	5.9	5.4	5.0	4.7	4.4	4.1

Instructions:

1. No interpolation allowed.
2. Using total insulation R-value (DHW-3, line 3) and tank volume (DHW-3, line 4), find jacket loss.
3. Enter jacket loss (JL) on line 7, DHW-3.

Table 6-8– Solar Fractions Table

		Conditioned Floor Area (ft²)																				
		726 to 774	775 to 824	825 to 874	875 to 924	925 to 974	975 to 1049	1050 to 1149	1150 to 1249	1250 to 1349	1350 to 1449	1450 to 1549	1550 to 1649	1650 to 1749	1750 to 1849	1850 to 1949	1950 to 2049	2050 to 2149	2150 to 2249	2250 to 2349	2350 to 2499	≥2500
Solar Energy Factors	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.1	0.16	0.15	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.12	0.12	0.12	0.11	0.11	0.10	0.10	0.10	0.10	0.09	0.09	0.09
	1.2	0.29	0.28	0.28	0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.22	0.21	0.20	0.20	0.19	0.19	0.18	0.18	0.17	0.17	0.16
	1.3	0.40	0.39	0.38	0.37	0.37	0.36	0.35	0.34	0.32	0.31	0.30	0.29	0.28	0.27	0.27	0.26	0.25	0.24	0.24	0.23	0.22
	1.4	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.40	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.27
	1.5	0.57	0.56	0.55	0.54	0.53	0.52	0.50	0.48	0.47	0.45	0.44	0.42	0.41	0.40	0.38	0.37	0.36	0.35	0.34	0.33	0.32
	1.6	0.65	0.63	0.62	0.61	0.59	0.58	0.57	0.55	0.53	0.51	0.49	0.47	0.46	0.45	0.43	0.42	0.41	0.40	0.38	0.37	0.36
	1.7	0.70	0.69	0.68	0.67	0.65	0.64	0.62	0.60	0.58	0.56	0.54	0.52	0.50	0.49	0.47	0.46	0.45	0.43	0.42	0.41	0.40
	1.8	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.62	0.60	0.58	0.56	0.54	0.53	0.51	0.50	0.48	0.47	0.46	0.44	0.43
	1.9	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.66	0.64	0.62	0.60	0.58	0.56	0.55	0.53	0.51	0.50	0.49	0.47	0.45
	2.0	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.65	0.63	0.61	0.59	0.58	0.56	0.54	0.53	0.51	0.50	0.48
	2.1	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.66	0.64	0.62	0.60	0.59	0.57	0.55	0.54	0.52	0.50
	2.2	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.61	0.59	0.58	0.56	0.54	0.52
	2.3	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.61	0.60	0.58	0.56	0.54
	2.4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.62	0.60	0.58	0.56
	2.5	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.62	0.60	0.58
	2.6	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.61	0.59
	2.7	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.66	0.65	0.63	0.60
	2.8	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.66	0.64	0.62
	2.9	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63
	3.0	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.67	0.64
	3.1	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.65
	3.2	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.66
	3.3	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.67
	3.4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68
	3.5	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69
	>3.5	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

Table 6-9– Wood Stove Boiler Credit Factors

	Credit Factors	
Climate Zone	**With Pump**	**Without Pump**
1	0.225	0.250
2	0.225	0.250
3	0.225	0.250
4	0.135	0.150
5	0.135	0.150
6	0.090	0.100
7	0.090	0.100
8	0.045	0.050
9	0.090	0.100
10	0.045	0.050
11	0.090	0.100
12	0.135	0.150
13	0.090	0.100
14	0.090	0.100
15	0.000	0.000
16	0.270	0.300

Table 6-10– Climate Zone Factors

Climate Zone	Climate Zone Factor
1, 14	1.04
2, 3	0.99
4, 5, 12	1.07
6-11, 13, 15	0.92
16	1.50

Case Studies

This Part explains how to demonstrate water-heating compliance for a number of common and unusual water heating systems.

Example 6-1 – Single Family, Gas Water Heater

Single family residence with one non-recirculating 40-gallon gas water heater.

This qualifies as a standard water heating system and complies automatically. No water heating calculations are required, although they may be performed to take credit for a particularly efficient water heater. See also Section 6.6.

Example 6-2 – Single Family, Heat Pump Water Heater

Single family residence with one non-recirculating 40-gallon heat pump water heater (EF=1.9) in Climate Zone 12.

Since the minimum EF for a heat pump water heater is 1.8, and this system meets that and all other requirements, it qualifies as a standard water heating system and complies automatically. No water heating calculations are required, although they may be completed at the option of the person submitting compliance documentation. See also Section 6.6.

Example 6-3 – Single Family, Two Gas Storage Tank Water Heaters

1,800 ft^2 single family residence with two identical 30-gallon gas storage tank water heaters and a point of use distribution system.

Water heating calculations are required for this system, including forms DHW-1 and DHW-2A. Form DHW-1 calculates Proposed Energy Use for the single water heater type. Credit for the Point of Use distribution system is also included on Form DHW-1. Form DHW-2A calculates the building's combined Total Proposed Energy Use, and compares it against the building's Standard Energy Use.

Example 6-4 – Single Family, Three Gas Storage Tank Water Heaters

6,000-ft^2 single family residence with 3 storage gas water heaters (40 gallon, 30 gallon and a 100-gallon unit with 80,000 Btuh input).

Water heating calculations are required for this system, including forms DHW-1, DHW-2A and DHW-3. Form DHW-1 calculates Proposed Energy Use for each individual water heater. Form DHW-3 calculates the Basic Energy Use factor for the 100-gallon water heater because its input is greater than 75,000 Btuh. Form DHW-2A calculates the building's combined Total Proposed Energy Use for the three water heaters, and compares it against the building's Standard Energy Use.

Note: Because the total floor area is greater than 2,500-ft^2, the Standard Recovery Load and Standard Energy Use for the building from Table 6-5 equal that for a 2,500-ft2 house.

Example 6-5 – Multi-family, Separate Gas Water Heaters for each Unit

10-unit multi-family building with separate gas water heaters for each dwelling unit. Five units have 30-gallon water heaters, and five units have 50-gallon water heaters.

Water heating calculations are not required if each system is non-recirculating because each dwelling unit has a standard water heating system.

Example 6-6 – Multi-family, Temperature Controlled Recirculation System

8-unit, 7,800-ft^2 multi-family building with a 200-gallon storage gas water heater and temperature controlled recirculation system serving all units.

Water heating calculations are required for this system, including forms DHW-1, DHW-2B and DHW-3. See Figure 6-3 through Figure 6-6 for the completed forms for this example.

In this situation, the correct approach is to use Form DHW-2B to calculate the average size of each dwelling unit within the building and the basic energy use per average unit.

Because a 200 gallon water heater has an input rating over 75,000 Btuh, it is necessary to use Form DHW-3 to calculate its Basic Energy Use for insertion on Line 9a of Form DHW-2B.

DHW-1 compares Proposed Energy Use to Standard Energy Use for the average dwelling unit. The Proposed Energy Use includes a penalty for the recirculation system with temperature controls.

Example 6-7 – Single Family Addition, Replacing Existing Water Heating System

Existing 1,500 ft^2 single family residence with 500 ft^2 addition. A new 50-gallon gas storage tank water heater will replace the existing water heating system.

Since this is an alteration to an existing water heating system, no water heating calculations are required. Building energy compliance for the addition may be demonstrated for either the addition alone or for the existing-plus-addition.

Example 6-8 – Single Family Existing, New Instantaneous Gas Water Heater

Existing 2,000-ft2 single family residence with one 50-gallon gas water heater; a 600 ft^2 addition with a new instantaneous gas water heater is proposed.

When there is an increase in the number of water heaters with an addition, the standards allow addition alone compliance in certain circumstances. Since this is an instantaneous gas water heater, if it can be demonstrated that it uses no more energy than a 50-gallon gas non-recirculating storage tank (see Table 6-2), then no water heating calculations are submitted.

Another alternative is to show existing-plus-addition compliance. See Figure 6-7 and Figure 6-8 for the completed forms for this case.

Default assumptions are used for the existing water heater (see Table 6-3 for default assumptions). For the existing-plus-addition portion of the analysis, a second Form DHW-1 calculates water heater type, and Form DHW-2A calculates the building's combined Total Proposed Energy Use, and compares it against the whole building's Standard Energy Use.

Note: For instantaneous gas water heaters, Recovery Energy must be calculated using the instructions at the end of Table 6-7D before finding Basic Energy Use.

Example 6-9 – Single Family, Non-recirculating Gas Water Heater

Single family residence with one non-recirculating 50 gallon gas water heater. The water heater has an input rating of 76,000 Btu/hr.

Even though this water heater has an input rating greater than 75,000 Btu/hr, it still qualifies as a standard water heater because it is a storage gas heater of 50 gallons or less. The system still qualifies as a standard water heating system because it meets all of the stated requirements. No water heating calculations are required, and the system complies automatically. See also Section 6.6.

Example 6-10 – Single Family, Existing+Addition, Electric Water Heater

Existing single family residence with one electric water heater; a 500 ft^2 addition with a 30-gallon electric water heater is proposed.

When there is an increase in the number of water heaters with an addition, the Standards allow addition alone compliance in certain circumstances. If this residence does not have natural gas connected to the building and the new water heater has an EF of 0.90 or greater, the system automatically complies (see Table 7-2). No water heating calculations are submitted.

Example 6-11 – Single Family, Replacement Gas Water Heater

A single family residence with one gas water heater is replacing the water heater with a new gas water heater.

This system must comply with the mandatory requirements for alterations. This includes a certified water heater and pipe insulation on the first five feet of hot and cold water pipes. Since compliance with the annual water heating budget is not required, no water heating calculations are required.

Example 6-12 – Residential Building, Gas to Electric Water Heater

A residential building is replacing a gas water heating system with an electric water heating system.

In addition to complying with mandatory requirements mentioned in Example 6-12, changing from gas to electric is prohibited (see Section 7.2) unless it “can be demonstrated that the source energy use of the new system is more efficient than the existing system.”

Alterations can also show compliance using an “existing-plus-alteration” compliance approach, as explained in Section 7.2. This approach could be used to take credit for improvements to the building being made to offset the water heating changes.

Figure 6-3– Example 6-6 DHW-1 Form – Multi-Family with Central System

WATER HEATING WORKSHEET — DHW-1

Project Title: Multi-Family w/Central System — Date: July 1, 1999

No. of Different Water Heater Types: 1 — Total No. of Water Heaters: 1 — Conditioned Floor Area (CFA): 7800 ft²

Notes: For single family dwellings with multiple water heaters, also submit DHW-2A. For multi-family buildings, also submit DHW-2B.

Heater Type # 1 Data

A. **Water Heater Type** (check one)
___ Storage Gas
✓ Large Storage Gas
___ Storage Electric
___ Storage Heat Pump
___ Instantaneous Gas
___ Instantaneous Electric
___ Indirect Gas

B. **Manufacturer** SoHot
C. **Model No.** G200
D. **Energy Factor** NA
E. **Gallons** 200
F. **Pilot Btu/hr** NA
G. Thermal **Eff.** 0.78

H. **Auxiliary Input** (check one or both)
___ Wood Stove
___ Solar, Active or Passive

I. **Distribution System** (check one)
___ Standard
___ Hot Water Recovery (HWR)
___ Point of Use (POU)
___ Pipe Insulation (PI)
___ Recirculation: No Control
___ Recirculation: Timer
✓ Recirculation: Temp.
___ Recirculation: Time/Temp.
___ Recirculation: Demand
___ HWR + Recirculation: Demand
___ PI + Recirculation: Demand

Energy Use Calculation
1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b) 9.7
1b. Distribution Credit/Penalty (from Table 6-6) -0.5
1c. Solar Energy Credit (from DHW-4) 0
1d. Adjusted Recovery Load (1a - 1b - 1c) 10.2
2a. Basic Energy Use (from Table 6-7) 16.7
2b. Wood Stove Boiler Credit (from DHW-4) 0
2c. **Proposed Energy Use** (2a - 2b) $\boxed{16.7}$
3. **Standard Energy Use** (from Table 6-5) $\boxed{18.8}$

Heater Type #_____ Data

A. **Water Heater Type** (check one)
___ Storage Gas
___ Large Storage Gas
___ Storage Electric
___ Storage Heat Pump
___ Instantaneous Gas
___ Instantaneous Electric
___ Indirect Gas

B. **Manufacturer** ___________
C. **Model No.** ___________
D. **Energy Factor** ________
E. **Gallons** ________
F. **Pilot Btu/hr** ________
G. Thermal **Eff.** ________

H. **Auxiliary Input** (check one or both)
___ Wood Stove
___ Solar, Active or Passive

I. **Distribution System** (check one)
___ Standard
___ Hot Water Recovery (HWR)
___ Point of Use (POU)
___ Pipe Insulation (PI)
___ Recirculation: No Control
___ Recirculation: Timer
___ Recirculation: Temp.
___ Recirculation: Time/Temp.
___ Recirculation: Demand
___ HWR + Recirculation: Demand
___ PI + Recirculation: Demand

Energy Use Calculation
1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b) ______
1b. Distribution Credit/Penalty (from Table 6-6) ______
1c. Solar Energy Credit (from DHW-4) ______
1d. Adjusted Recovery Load (1a - 1b - 1c) ______
2a. Basic Energy Use (from Table 6-7) ______
2b. Wood Stove Boiler Credit (from DHW-4) ______
2c. **Proposed Energy Use** (2a - 2b) ☐
3. **Standard Energy Use** (from Table 6-5) ☐

Heater Type #_____ Data

A. **Water Heater Type** (check one)
___ Storage Gas
___ Large Storage Gas
___ Storage Electric
___ Storage Heat Pump
___ Instantaneous Gas
___ Instantaneous Electric
___ Indirect Gas

B. **Manufacturer** ___________
C. **Model No.** ___________
D. **Energy Factor** ________
E. **Gallons** ________
F. **Pilot Btu/hr** ________
G. Thermal **Eff.** ________

H. **Auxiliary Input** (check one or both)
___ Wood Stove
___ Solar, Active or Passive

I. **Distribution System** (check one)
___ Standard
___ Hot Water Recovery (HWR)
___ Point of Use (POU)
___ Pipe Insulation (PI)
___ Recirculation: No Control
___ Recirculation: Timer
___ Recirculation: Temp.
___ Recirculation: Time/Temp.
___ Recirculation: Demand
___ HWR + Recirculation: Demand
___ PI + Recirculation: Demand

Energy Use Calculation
1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b) ______
1b. Distribution Credit/Penalty (from Table 6-6) ______
1c. Solar Energy Credit (from DHW-4) ______
1d. Adjusted Recovery Load (1a - 1b - 1c) ______
2a. Basic Energy Use (from Table 6-7) ______
2b. Wood Stove Boiler Credit (from DHW-4) ______
2c. **Proposed Energy Use** (2a - 2b) ☐
3. **Standard Energy Use** (from Table 6-5) ☐

4. **For Prescriptive Compliance** (one water heater per dwelling): Line 2c must not exceed Line 3

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Figure 6-4– Example 6-6 DHW-1 Form – Multi-Family with Central System

WATER HEATING WORKSHEET **DHW-1**

Project Title: Multi-Family w/Central System   Date: July 1, 1999

No. of Different Water Heater Types: 1   Total No. of Water Heaters: 1   Conditioned Floor Area (CFA): 7800 ft²

Notes: For single family dwellings with multiple water heaters, also submit DHW-2A. For multi-family buildings, also submit DHW-2B.

Heater Type # 1 Data	Heater Type # ___ Data	Heater Type # ___ Data
A. Water Heater Type (check one)	**A. Water Heater Type** (check one)	**A. Water Heater Type** (check one)
___ Storage Gas	___ Storage Gas	___ Storage Gas
✓ Large Storage Gas	___ Large Storage Gas	___ Large Storage Gas
___ Storage Electric	___ Storage Electric	___ Storage Electric
___ Storage Heat Pump	___ Storage Heat Pump	___ Storage Heat Pump
___ Instantaneous Gas	___ Instantaneous Gas	___ Instantaneous Gas
___ Instantaneous Electric	___ Instantaneous Electric	___ Instantaneous Electric
___ Indirect Gas	___ Indirect Gas	___ Indirect Gas
B. Manufacturer SoHot	**B. Manufacturer** ___	**B. Manufacturer** ___
C. Model No. G200	**C. Model No.** ___	**C. Model No.** ___
D. Energy Factor NA	**D. Energy Factor** ___	**D. Energy Factor** ___
E. Gallons 200	**E. Gallons** ___	**E. Gallons** ___
F. Pilot Btu/hr NA	**F. Pilot Btu/hr** ___	**F. Pilot Btu/hr** ___
G. Thermal Eff. 0.78	**G. Thermal Eff.** ___	**G. Thermal Eff.** ___
H. Auxiliary Input (check one or both)	**H. Auxiliary Input** (check one or both)	**H. Auxiliary Input** (check one or both)
___ Wood Stove	___ Wood Stove	___ Wood Stove
___ Solar, Active or Passive	___ Solar, Active or Passive	___ Solar, Active or Passive
I. Distribution System (check one)	**I. Distribution System** (check one)	**I. Distribution System** (check one)
___ Standard	___ Standard	___ Standard
___ Hot Water Recovery (HWR)	___ Hot Water Recovery (HWR)	___ Hot Water Recovery (HWR)
___ Point of Use (POU)	___ Point of Use (POU)	___ Point of Use (POU)
___ Pipe Insulation (PI)	___ Pipe Insulation (PI)	___ Pipe Insulation (PI)
___ Recirculation: No Control	___ Recirculation: No Control	___ Recirculation: No Control
___ Recirculation: Timer	___ Recirculation: Timer	___ Recirculation: Timer
✓ Recirculation: Temp.	___ Recirculation: Temp.	___ Recirculation: Temp.
___ Recirculation: Time/Temp.	___ Recirculation: Time/Temp.	___ Recirculation: Time/Temp.
___ Recirculation: Demand	___ Recirculation: Demand	___ Recirculation: Demand
___ HWR + Recirculation: Demand	___ HWR + Recirculation: Demand	___ HWR + Recirculation: Demand
___ PI + Recirculation: Demand	___ PI + Recirculation: Demand	___ PI + Recirculation: Demand
Energy Use Calculation	**Energy Use Calculation**	**Energy Use Calculation**
1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b): 9.7	1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b): ___	1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b): ___
1b. Distribution Credit/Penalty (from Table 6-6): -0.5	1b. Distribution Credit/Penalty (from Table 6-6): ___	1b. Distribution Credit/Penalty (from Table 6-6): ___
1c. Solar Energy Credit (from DHW-4): 0	1c. Solar Energy Credit (from DHW-4): ___	1c. Solar Energy Credit (from DHW-4): ___
1d. Adjusted Recovery Load (1a - 1b - 1c): 10.2	1d. Adjusted Recovery Load (1a - 1b - 1c): ___	1d. Adjusted Recovery Load (1a - 1b - 1c): ___
2a. Basic Energy Use (from Table 6-7): 16.7	2a. Basic Energy Use (from Table 6-7): ___	2a. Basic Energy Use (from Table 6-7): ___
2b. Wood Stove Boiler Credit (from DHW-4): 0	2b. Wood Stove Boiler Credit (from DHW-4): ___	2b. Wood Stove Boiler Credit (from DHW-4): ___
2c. **Proposed Energy Use** (2a - 2b): 16.7	2c. **Proposed Energy Use** (2a - 2b): ___	2c. **Proposed Energy Use** (2a - 2b): ___
3. **Standard Energy Use** (from Table 6-5): 18.8	3. **Standard Energy Use** (from Table 6-5): ___	3. **Standard Energy Use** (from Table 6-5): ___

4. **For Prescriptive Compliance** (one water heater per dwelling): Line 2c must not exceed Line 3

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Figure 6-5– Example 6-6 DHW-2B Form – Multi-Family with Central System

WATER HEATING FOR MULTI-FAMILY BUILDINGS **DHW-2B**

Multi-Family w/Central System — Project Title
July 1, 1999 — Date

Notes: In addition to this form, a DHW-1 Water Heating Worksheet must also be submitted to document water heating type(s). If the calculation (line 4) is by "Individual Dwelling Unit" and system configuration (line 5) is "Individual Heaters," no additional information need be entered on this sheet.

Multi-Family Project Data

1. Number of dwelling units: 8
2. Total conditioned floor area: 7800 ft²
3. Average floor area: 975 (Line 2/Line 1)
4. Calculation by (check one): ✓ Average Dwelling Unit; ___ Individual Dwelling Unit
5. System configuration (check one): ___ Individual Heaters (one per dwelling unit); ✓ Shared Heaters (multiple dwelling units per heater)

Analysis by Average Dwelling Unit

One Individual Heater Per Dwelling Unit

	No. of Heaters	Heater Type¹	Manufacturer and Model##	Gallons Each	Gallons Total¹	Energy Factor Each	Energy Factor Total²	Thermal Efficiency Each	Thermal Efficiency Total³
8a =	1	#1	SoHot G200						
8b =		#2							
8c =		#3							
Total	1 = 7a			Total	= 7b	Total	= 7c	Total	= 7d
				Ave.	= 8a (7b/7a)	Ave.	= 8b (7c/7a)	Ave.	= 8c (7d/7a)

Individual Heaters

9a. Enter value 8a on DHW-1 Line E.
10a. Enter value 8b on DHW-1 Line D.
11a Enter value 8c on DHW-1 line G.
12a. Check compliance on DHW-1 for average dwelling unit and average water heating.

Shared Heater(s)

9b. Average unit Adjusted Recovery Load: 10.2 From DHW-1, Line 1d
10b. Total Adjusted Recovery Load: 81.6 (Line 1) × (Line 9b)
11b. Total Basic Energy Use: 93.8 From Table 6-7, or DHW-3
12b. Average Unit Basic Energy Use: 11.7 (Line 11b) ÷ (Line 1): enter on Line 2a, DHW-1
13b. Check average unit compliance on DHW-1.

Compliance

14. **Prescriptive Compliance** (for individual or shared heaters):
DHW-1 Line 2c must be equal to or less than DHW-1 Line 3.
See Part 6.1 and Chapter 3 in the *Residential Manual* for details.

¹ Total Gallons = (No. of Heaters) x (Gallons for each heater of this Heater Number)
² Total Energy Factor = (No. of Heaters) x (Energy Factor for each heater of this Heater Number)
³ Total Thermal Efficiency = (No. of Heaters) x (Thermal Efficiency for each heater of this Heater Number)

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Figure 6-6– Example 6-6 DHW-3 Form – Multi-Family with Central System

INDIRECT & LARGE STORAGE GAS WATER HEATERS **DHW-3**

Multi-Family w/Central System — Project Title
July 1, 1999 — Date

Note: This sheet must also be submitted with a DHW-1 water heating worksheet, as well as a DHW-2B form with large storage gas heaters in multi-family buildings.

Indirect Gas Water Heaters

1. Storage tank Manufacturer/Model No. ________
2. Boiler and Instantaneous Heater Manufacturer/Model No. ________
3. Storage tank insulation R-value: Tank ____ External ____ Total ____
4. Storage tank volume (gallons) ____
5. Boiler AFUE or Instantaneous Water Heater Thermal (Recovery) Efficiency EFF ____
6. Adjusted Recovery Load (MBtu/yr, from Line 1d, DHW-1) ARL ____
7. Jacket loss (MBtu/yr, from Table 6-7E) JL ____
8. Pilot Energy (Btuh, from appliance database, or use 800) PE ____
9. Basic Energy Use (BEU) = (ARL + JL) ÷ (0.98 × EFF) + (PE × 0.00876) BEU ____
   (Enter BEU on DHW-1, Line 2a or on DHW-2B, Line 11b)

Large Storage Gas Heaters (> 75,000 Btuh input)

1. Water Heater Manufacturer SoHot
2. Water Heater Model No. G200
3. Storage Tank Volume (gallons) VOL= 200
4. Water Heater Thermal (Recovery) Efficiency (decimal fraction) EFF 0.78
5. Adjusted Recovery Load (Mbtu/yr, from Line 1d, DHW-1 or Line 10b, DHW-2B) ARL 81.6
6. Standby Loss % (from appliance database - e.g., "2.7") SBL% 2.5
7. Basic Energy Use (BEU) = [ARL/EFF + (5.461 × SBLxVOL)/100] BEU 133.5
   (Enter BEU on DHW-1, Line 2a or on DHW-2B, Line 11b)

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Figure 6-7– Example 6-8 DHW-1 for Existing + Addition

WATER HEATING WORKSHEET **DHW-1**

Project Title: Jones Residence: Existing & Addition Date: July 1, 1999

No. of Different Water Heater Types: 2 Total No. of Water Heaters: 2 Conditioned Floor Area (CFA): 2600 ft2

Notes: For single family dwellings with multiple water heaters, also submit DHW-2A. For multi-family buildings, also submit DHW-2B.

Heater Type # 1 Data	Heater Type # 2 Data	Heater Type # ____ Data
A. Water Heater Type (check one)	**A. Water Heater Type** (check one)	**A. Water Heater Type** (check one)
✓ Storage Gas	___ Storage Gas	___ Storage Gas
___ Large Storage Gas	___ Large Storage Gas	___ Large Storage Gas
___ Storage Electric	___ Storage Electric	___ Storage Electric
___ Storage Heat Pump	___ Storage Heat Pump	___ Storage Heat Pump
___ Instantaneous Gas	✓ Instantaneous Gas	___ Instantaneous Gas
___ Instantaneous Electric	___ Instantaneous Electric	___ Instantaneous Electric
___ Indirect Gas	___ Indirect Gas	___ Indirect Gas
B. Manufacturer So Hot	**B. Manufacturer** GTherm	**B. Manufacturer** ____
C. Model No. G40	**C. Model No.** I-00	**C. Model No.** ____
D. Energy Factor 0.60	**D. Energy Factor** NA	**D. Energy Factor** ____
E. Gallons 40	**E. Gallons** NA	**E. Gallons** ____
F. Pilot Btu/hr NA	**F. Pilot Btu/hr** 300	**F. Pilot Btu/hr** ____
G. Thermal Eff. NA	G. Thermal Eff. 0.80	G. Thermal Eff. ____
H. Auxiliary Input (check one or both)	**H. Auxiliary Input** (check one or both)	**H. Auxiliary Input** (check one or both)
___ Wood Stove	___ Wood Stove	___ Wood Stove
___ Solar, Active or Passive	___ Solar, Active or Passive	___ Solar, Active or Passive
I. Distribution System (check one)	**I. Distribution System** (check one)	**I. Distribution System** (check one)
✓ Standard	✓ Standard	___ Standard
___ Hot Water Recovery (HWR)	___ Hot Water Recovery (HWR)	___ Hot Water Recovery (HWR)
___ Point of Use (POU)	___ Point of Use (POU)	___ Point of Use (POU)
___ Pipe Insulation (PI)	___ Pipe Insulation (PI)	___ Pipe Insulation (PI)
___ Recirculation: No Control	___ Recirculation: No Control	___ Recirculation: No Control
___ Recirculation: Timer	___ Recirculation: Timer	___ Recirculation: Timer
___ Recirculation: Temp.	___ Recirculation: Temp.	___ Recirculation: Temp.
___ Recirculation: Time/Temp.	___ Recirculation: Time/Temp.	___ Recirculation: Time/Temp.
___ Recirculation: Demand	___ Recirculation: Demand	___ Recirculation: Demand
___ HWR + Recirculation: Demand	___ HWR + Recirculation: Demand	___ HWR + Recirculation: Demand
___ PI + Recirculation: Demand	___ PI + Recirculation: Demand	___ PI + Recirculation: Demand
Energy Use Calculation	**Energy Use Calculation**	**Energy Use Calculation**
1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b) 7.8	1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b) 7.8	1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b) ____
1b. Distribution Credit/Penalty (from Table 6-6) 0	1b. Distribution Credit/Penalty (from Table 6-6) 0	1b. Distribution Credit/Penalty (from Table 6-6) ____
1c. Solar Energy Credit (from DHW-4) 0	1c. Solar Energy Credit (from DHW-4) 0	1c. Solar Energy Credit (from DHW-4) ____
1d. Adjusted Recovery Load (1a - 1b - 1c) 7.8	1d. Adjusted Recovery Load (1a - 1b - 1c) 7.8	1d. Adjusted Recovery Load (1a - 1b - 1c) ____
2a. Basic Energy Use (from Table 6-7) 15.7	2a. Basic Energy Use (from Table 6-7) 12.4	2a. Basic Energy Use (from Table 6-7) ____
2b. Wood Stove Boiler Credit (from DHW-4) ____	2b. Wood Stove Boiler Credit (from DHW-4) 0	2b. Wood Stove Boiler Credit (from DHW-4) ____
2c. Proposed Energy Use (2a - 2b) ☐	**2c. Proposed Energy Use** (2a - 2b) 12.4	**2c. Proposed Energy Use** (2a - 2b) ☐
3. Standard Energy Use (from Table 6-5) —	**3. Standard Energy Use** (from Table 6-5) —	**3. Standard Energy Use** (from Table 6-5) ☐

4. **For Prescriptive Compliance** (one water heater per dwelling): Line 2c must not exceed Line 3

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Figure 6-8– Example 6-8 DHW-2A for Existing + Addition

SINGLE FAMILY W/ MULTIPLE WATER HEATERS **DHW-2A**

Jones Residence: Existing + Addition — Project Title

July 1, 1999 — Date

Note: In addition to this form, a DHW-1 Water Heating Worksheet must also be submitted to document water heater type(s).

Single Family Project Data

1. No. of different water heater types: 2
2. Total conditioned floor area: 2500 ft²

	No. of Heaters	Heater Type #	Manufacturer & Model No.
3a.	1	#1	SoHot G40
3b.	1	#2	GTherm I00
3c.		#3	

4. 2 Total Number of Water Heaters
5. Standard Recovery Load: 15.6 from Table 6-5 based on line 2
6. Recovery Load Per Heater: 7.8 (line 5 ÷ line 4); enter on DHW-1, line 1a for each Heater Type, and complete calculation through line 2c.
7. Proposed Energy Use, Heater #1: 15.7 (from DHW-1 line 2c, Heater #1) × (line 3a)
8. Proposed Energy Use, Heater #2: 10.4 (from DHW-1 line 2c, Heater #2) × (line 3b)
9. Proposed Energy Use, Heater #3: — (from DHW-1 line 2c, Heater #3) × (line 3c)
10. Total Proposed Energy Use: 26.1 (line 7 + line 8 + line 9)
11. Standard Energy Use: 26.1 from Table 6-5 based on line 2

Compliance

12. **Prescriptive Compliance:** Line 10 must be equal to or less than line 11. See Part 6.1 and Chapter 3 in the *Residential Manual* for details.

July 1, 1999

Combined Hydronic Space and Water Heating

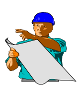
Section 8.9 explains hydronic space heating systems. When such a system serves the additional function of providing domestic hot water, the system is analyzed for its water heating performance as if the space heating function were separate. In other words, treat any hydronic system used for water heating the same as any other water heating system: Input the correct water heater type, auxiliary input credit (if any) and specify the distribution system on DHW-1.

The DHW-5 is used to calculate an effective AFUE or to adjust the AFUE for pipe losses when a space heating boiler is also used for water heating (see Section 6.3).

Complete the DHW-5 worksheet for any project that includes a hydronic space heating system, combined hydronic space and water heating system, or boiler (see Section 6.3). This worksheet should accompany all necessary water heating compliance worksheets. The DHW-5 worksheet is used to determine the Effective AFUE for storage gas water heaters and the Effective HSPF for storage electric and heat pump water heaters used to supply energy for the combined hydronic space and water heating system.

For performance compliance, the water heating worksheets are not printed, but the inputs will appear on the C-2R and CF-1R forms.

System Descriptions



System Types and Installation

The water heating calculation method evaluates water heating systems by analyzing the following system components: Water Heaters, Auxiliary Systems, and Distribution Systems. Separate calculations are required for Hydronic Space and Water Heating Systems. This part describes all of the system types that fall within each category, and explains installation criteria.

Water Heaters

This part describes water heater types that can be analyzed using the water heating method:

- Standard Water Heater
- Storage Gas
- Large Storage Gas
- Storage Electric
- Storage Heat Pump
- Instantaneous Gas
- Instantaneous Electric
- Indirect Gas

All water heaters must be certified (see Section 1.6). This guarantees that they meet the minimum requirements of the National Efficiency Standards and State Efficiency Standards as described in the California Appliance Efficiency Regulations.

For small storage gas water heaters this corresponds to an Energy Factor = 0.62 - (0.0019 x Volume).

For small storage electric water heaters the minimum is an Energy Factor = 0.93 - (0.00132 x Volume).

Standard Water Heater

A standard water heater is one that automatically complies with the standards, since its characteristics meet the installation criteria described below. For a system in a single family dwelling consisting of a single standard water heater and a standard distribution system, compliance is demonstrated by listing water heater type and distribution system on form CF-1R. No other water heating calculations are required.

Installation Criteria:

One gas water heater of 50-gallons capacity or less per dwelling unit. On any unit with an EF of less than 0.58, R-12 external insulation is mandatory.

Storage Gas

A gas water heater designed to heat and store water at less than 180°F. Water temperature is controlled with a thermostat. Storage gas water heaters have a manufacturer's specified storage capacity of at least two gallons and less than 75,000 Btuh input.

Large Storage Gas
A storage gas water heater with greater than 75,000 Btuh input.

Storage Electric

An electric water heater designed to heat and store water at less than 180 °F. Water temperature is controlled with a thermostat. Storage electric water heaters have a manufacturer's specified storage capacity of at least two gallons.

Storage Heat Pump
An electric water heater that uses a compressor to transfer thermal energy from one temperature level to a higher temperature level for the purpose of heating water. It includes all necessary auxiliary equipment such as fans, storage tanks, pumps or controls. EFs for heat pump water heaters are found in the Commission's Directory of Certified Water Heaters.

Instantaneous Gas
A gas water heater controlled manually or automatically by a water flow activated control or a combination of water flow and thermostatic controls, with a manufacturer's specified storage capacity of less than two gallons.
Recovery efficiency and pilot energy are in the Commission's database of certified water heaters.

Instantaneous Electric
An electric water heater controlled automatically by a thermostat, with a manufacturer's specified storage capacity of less than two gallons.

Note: Instantaneous water heaters are not generally designed for use with solar water heating systems or as heat sources for indirect fired water heaters. They are also typically inappropriate for use with recirculation systems. Consult manufacturer's literature when considering these applications.

Indirect Gas
A water heater consisting of a storage tank with no heating elements or combustion devices, connected via piping and recirculating pump to a heat source consisting of a gas or oil fired boiler, or instantaneous gas water heater (see note following the definitions of Instantaneous Gas and Electric).
Installation Criteria:
The storage tank must be insulated in accordance with Section 150(j)1.B. of the standards, which requires a factory-installed minimum of R-16 (labeled on outside of tank) or a minimum of R-12 external insulation (see Section 2.6).
The piping connecting the heating source and the storage tank must be insulated to R-4 for pipe less than or equal to 2 inches in diameter, and to R-6 for pipes larger than 2 inches in diameter. This includes any piping located in concrete slabs or underground.

External Tank Insulation
Insulation applied to the exterior of storage type water heater tanks.
When installed, water heater insulation should be applied to completely cover the exterior sides of water heaters, but should not conceal controls or access ports to burners, cover combustion air openings, or interfere in any way with safe water heater operation. Insulation of top and bottom surfaces is not necessary.
External tank insulation is mandatory for water heaters with less than 0.58 EF, and for unfired water heater tanks that do not have R-16 internal insulation (as indicated on the outside of the tank).

Auxiliary Systems

Auxiliary systems add hot water to the overall water heating system through means other than the typical water heaters defined above.

The Water Heating Calculation Method allows water heating credits for three auxiliary systems which save energy by using nondepletable resources as energy sources. These systems – Passive and Active Solar Water Heaters and Wood Stove Boilers – are described below.

Passive Solar Water Heaters

Systems which collect and store solar thermal energy for domestic water heating applications and do not require electrical energy input for recirculating water through a solar collector.

Installation Criteria:

Passive solar water heaters must be tested in accordance with Solar Rating & Certification Corporation (SRCC) Standard 200-82, except as noted below.

Thermosyphon solar water heaters employing flat plate collectors comply with test requirements if collectors are tested in accordance with SRCC Standard 100-81.

SRCC's address is:

Solar Rating and Certification Corporation
C/o FSEC, 1679 Clearlake Road
Cocoa, FL 32922-5703
(407) 638-1537
(407) 638-1010 (FAX)

Active Solar Water Heaters

Systems which collect and store solar thermal energy for domestic water heating applications requiring electrical energy input for operation of pumps or other components.

Installation Criteria:

Flat plate collectors used with active solar waters must be tested in accordance with SRCC Standard 100-81 (see address above).

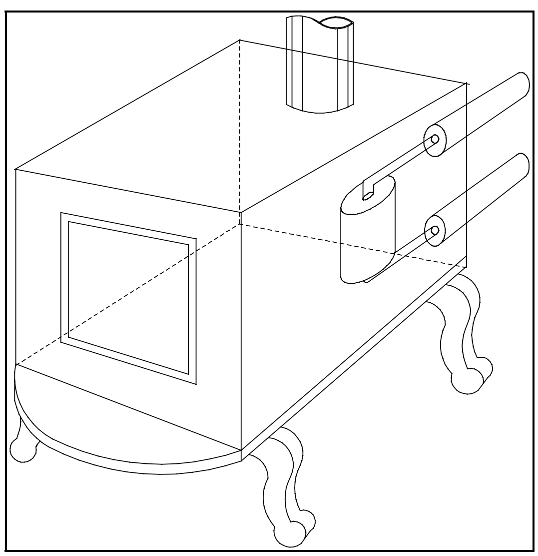
Wood Stove Boilers

Wood stoves equipped with heat exchangers for heating domestic hot water (see Figure 6-9).

Installation Criteria:

Energy credits may only be taken when the building department having jurisdiction has determined that natural gas is not available.

Figure 6-9– Wood Stove Boiler



A tempering valve must be installed at the outlet of the water heater to prevent scalding.

A pressure-temperature relief valve must be installed at the wood stove.

The wood stove boiler must be properly sized to minimize the amount of excess hot water produced by the unit.

All health and safety codes, including codes applying to pressurized boiler vessels, must be met.

Distribution Systems
The water heating distribution system is the configuration of piping, pumps and controls that regulates delivery of hot water from the water heater to all end uses within the building.
All criteria listed below are based on Commission contract #400-88-003, *Residential Water Heating Study*: March 31, 1991.
The water heating calculation method gives credits for especially energy-efficient distribution systems, while taking penalties for less energy-efficient systems (see Table 6-3). The distribution systems that may be analyzed are:

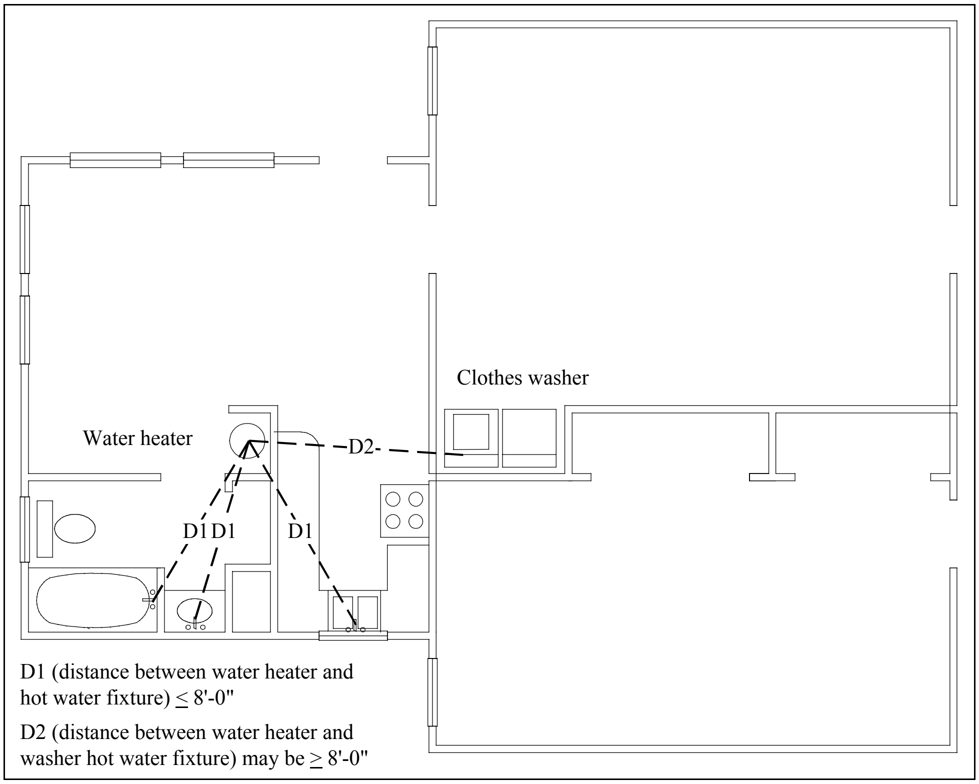
- Standard Distribution System
- Point of Use
- Hot Water Recovery
- Pipe Insulation
- Parallel Piping
- Recirculation: Continuous
- Recirculation: Temperature Controlled
- Recirculation: Time Controlled
- Recirculation: Time & Temperature Controlled
- Recirculation: Demand Pumping
- Hot Water Recovery + Recirculation: Demand Pumping
- Pipe Insulation + Recirculation: Demand Pumping

Only one distribution system type may be chosen for each water heating system, with the exception of recirculation systems with demand pumping which may be combined with **either** hot water recovery systems **or** pipe insulation. In either of these cases the two appropriate adjustment values from Table 6-6 are added together and input as Distribution Credit on form DHW-1.
Pipe insulation is required for all other recirculation systems (except Demand) and may not be used for extra credit (see Section 2.6).

Standard Distribution System
A standard distribution system does not incorporate a pump for recirculation of hot water, and does not take credit for any design features eligible for energy credits. A distribution system normally eligible for energy credits, such as one with pipe insulation, may be modeled as standard (i.e., no credits) to avoid the need for any water heating calculations.
Compliance for any water heating system in a single family house with standard distribution and only one standard water heater is demonstrated by listing the water heater type and distribution system on form CF-1R. No other water heating forms are required.
Installation Criteria:
No pumps may be used to recirculate hot water. The first five feet of hot and cold water piping adjacent to the water heater must be insulated with minimum R-4 insulation (see Section 2.6).

Point of Use
A distribution piping system that limits hot water distribution system heat loss by minimizing the distance between the water heater and hot water fixtures.
Credit for only one Point of Use may be taken even if additional water heaters meeting the criteria will be installed.
Installation Criteria:
The distance between the water heater and any hot water fixture cannot exceed eight feet, measured in plan view (see Figure 6-10).
All water heaters and hot water fixtures must be shown on plans submitted for local building department plan check.
EXCEPTION: Washing machines for clothing may be located more than eight feet from the water heater.

Figure 6-10– Point of Use



Hot Water Recovery System
A distribution system that includes a device that reclaims hot water from the distribution piping by drawing it back to the water heater or other insulated storage vessel.
Installation Criteria:
Hot water recovery systems (HWR) must be plumbed such that a positive supply of cold water from the water supply main is provided to the appropriate connection on the device.
Hot water recovery systems must be connected to each water heater serving individual dwelling units.
Credit for only one HWR may be taken even though more than one may be installed or specified in the building plans.
Credit may not be taken for a HWR in a multi-family central water heating system serving multiple dwelling units.
Hot water recovery systems may be used for credit in recirculation systems with demand pumping.

Pipe Insulation
Table 6-3 lists credits that may be taken for insulation of water mains in addition to insulation required by Section 150 of the Standards (first five feet from water heater). The pipe insulation credit is only allowed for 3/4 inch or larger, non-recirculating hot water mains and Demand Recirculating Systems.
Installation Criteria:
R-value of applied insulation must not be less than R-4.0, or less than R-6.0 for pipe diameters greater than 2 inches. No additional credit may be taken for R-4 or R-6 insulation, respectively (see Section 2.6.2). Pipe insulation may only be used for credit in recirculation systems with demand pump. *Pipe insulation is required for all other recirculation systems and is not eligible for credit.*

Note: Heat tape – electric resistance heating tape wrapped around hot water pipes – may be used only for freeze protection and cannot be used instead of mandatory pipe insulation (see Section 2.6.2) or pipe insulation receiving distribution credit.

Parallel Piping
A distribution system that limits the amount of heat loss and water lost from the distribution piping by minimizing the volume of hot water left in the pipes at the end of each water draw.

Credit for Parallel Piping can only be used if each hot water use location (each kitchen, each bathroom and each laundry area) has a separate distribution line with a maximum size of half-inch pipe run from the location of the water heater to each hot water use location.
Installation Criteria:
Adequate distribution piping must be supplied to meet the demand at each hot water use location as required by the plumbing code. No piping over one-half inch may be used with the exception of a manifold located within six feet of the water heater to which the half-inch piping runs are connected.
All water heaters, distribution line runs and fixture points must be shown on the plans.

Recirculation System
Continuous distribution system using a pump to recirculate hot water to branch piping though a looped hot water main with no control of the pump, such that water flow is continuous.
Installation Criteria:
All piping used to recirculate hot water must be insulated with R-4 insulation or equivalent. This includes any recirculating piping located in concrete slabs or underground. Since the standards require this insulation, it is not eligible for the Pipe Insulation credit.

Recirculation System: Temperature Controlled
Recirculation system that uses temperature controls to cycle pump operation to maintain circulated water temperatures within certain limits.
Installation Criteria:
All criteria listed for continuous recirculation systems apply.
An automatic thermostatic control must be installed to cycle the pump on and off in response to the temperature of water returning to the water heater through the recirculation piping. Minimum differential or "deadband" of the control shall not be less than 20°F.
Plans must indicate pump and control manufacturer, model number and temperature settings.

Recirculation System: Time Controlled
Recirculation system that uses a timer control to cycle pump operation based on time of day.
Installation Criteria:
All criteria listed for continuous recirculation systems apply.
A timer must be permanently installed to regulate pump operation. Timer setting must permit the pump to be cycled off for at least eight hours per day.
Plans must indicate pump and timer manufacturer and model number.

Recirculation System: Time and Temperature Controlled
Recirculation system that uses both temperature and timer controls to regulate pump operation.
Installation Criteria:
All criteria listed for continuous, temperature controlled, and timer controlled recirculation systems apply.

Recirculation System: Demand Pumping
Recirculation system that uses brief pump operation to recirculate hot water to fixtures on demand.
Installation Criteria:
All criteria listed for continuous recirculation systems apply, except that pipe insulation is not required.
Pump start-up must be provided by one or more momentary contact switches, or a hot water flow sensing device located at the water heater. Systems using momentary contact switches must have at least one switch at each floor level, one of which must be located at the kitchen sink.
Pump shut-off must be provided by either a temperature sensing device that shuts off the pump when the pipe is full of hot water, or by a timer which limits pump run time to two minutes or less.
Plans must include a wiring/circuit diagram, and manufacturer/model numbers for the pump and timer/temperature sensing device.
Demand systems can only be used for control of pumps serving one dwelling unit. They are not used for central systems in multi-family buildings.

Note: In an exception to the rule that distribution systems may not be combined, insulation *or* hot water recovery systems may be used for credit in recirculation systems with demand pumping (see below). Pipe insulation is required for all other recirculation systems, so it is not eligible for extra credit.
Recirculation systems are not used with instantaneous water heaters.

Hot Water Recovery + Recirculation System: Demand Pumping
This combination system receives both credits explained under each system, separately, above. Installation criteria for both credits – hot water recovery and demand recirculation – apply to this combined distribution type.

Pipe Insulation + Recirculation System: Demand Pumping
This combination system receives both credits explained under each system, separately, above. Installation criteria for both credits – pipe insulation and demand recirculation – apply to this combined distribution type.

Hydronic Space and Water Heating

Combined Hydronic Space and Water Heating
A combined water and space heating system using the same water heater to heat the building and to provide domestic hot water.
Installation Criteria:
Piping for pump recirculating hydronic space heating supply lines must be insulated to R-4 for pipes less than or equal to 2 inches nominal diameter and R-6 for larger pipe diameters.

Dedicated (Separate) Hydronic Space Heating
A system using separate water heaters to provide space heating and domestic hot water, each dedicated to one function.
Installation Criteria:
Piping for pump recirculating hydronic space heating supply lines must be insulated to R-4.0 for pipes 2 inches or less in diameter and to R-6.0 for larger pipe diameters. See the standards, §150(j).

Residential Lighting

Kitchen Lighting

§150(k)1, 3

1. *Luminaires for general lighting in kitchens shall have lamps with an efficacy of not less than 40 lumens per watt. General lighting must provide a sufficient light level for basic kitchen tasks and provide a uniform pattern of illumination. A luminaire(s) that is(are) the only lighting in a kitchen will be considered general lighting. General lighting shall be controlled by a switch on a readily accessible lighting control panel at an entrance to the kitchen.*
2. *Additional luminaires to be used only for specific decorative effects need not meet this requirement.*
3. *Luminaires installed to meet the 40 lumens per watt requirements of Section 150(k) 1. or 2. shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.*

Installing energy-efficient lamps and fixtures can reduce lighting energy costs without sacrificing the quality or quantity of light available. The intent of the kitchen lighting code is not to increase the number of light fixtures and/or watts used by the occupant but rather to ensure that the builder provides - and the occupant uses - energy efficient lighting. As indicated in Table 2-5, a 40-watt standard fluorescent lamp is over four times as efficient as a 100-watt standard incandescent lamp ('efficacy' is defined in §101(b) of the Standards as, "…the ratio of light from a lamp to the electrical power consumed (including ballast losses) expressed in lumens per watt").

General lighting is the lighting that the occupant will typically use on a regular basis (normally, but not necessarily, fluorescent lighting). If there is only one light in the kitchen, it is general lighting. IES guidelines recommend that at least 30 footcandles of light be provided for seeing tasks in kitchens. Seeing tasks include, but are not limited to, basic kitchen tasks such as preparing meals and washing dishes. These tasks typically occur on accessible kitchen countertops, the tops of ranges and in sinks, where food preparation, recipe reading, cooking, cleaning and related meal preparation activities take place, as well as at the front of kitchen cabinets.

The general lighting in kitchens must:

- Have an efficacy of *at least 40 lumens/watt* (see Table 2-5).
- Provide a uniform pattern of lighting, such as a fixture in the center of the kitchen or

around the perimeter (not a fixture in the corner).
- Provide a light level sufficient for performing basic kitchen tasks such as preparing meals and washing dishes.
- Be controlled on a readily accessible switch at an entrance to the kitchen (not in a cupboard or beside the kitchen sink).
- Be switched independent of incandescent lighting.
- Shall nNot contain medium-base incandescent lamp sockets. This prevents the occupant from replacing the efficient light source with an incandescent bulb.

Additional luminaires for decorative effect do not need to meet these requirements.

Incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with §150(k)4 (see below).

The lighting in the kitchen, either general or the only lighting, must:

- Be fluorescent or another product that has at least 40 lumens/watt (see Table 2-5).
- Provide a uniform pattern of lighting, such as a fixture in the center of the kitchen or around the perimeter (not a fixture in the corner).
- Provide a light level sufficient for performing basic kitchen tasks such as preparing meals and washing dishes.
- Be controlled on a readily accessible switch at an entrance to the kitchen (not in a cupboard or beside the kitchen sink).
- Be switched separately from incandescent lighting and on a control panel at an entrance to the kitchen.
- Not contain medium-base incandescent lamp sockets. This prevents the occupant from replacing the efficient light source with an incandescent bulb.

To clearly demonstrate compliance with the Standards to a building department, a lighting layout design that includes a point-by-point illuminance grid for the high-efficacy lighting may be provided. To do this properly, this grid must account for the room geometry, fixture placement, coefficient of utilization (CU) of the fixtures, lamp lumens, lamp lumen depreciation, and reflectivity of all of the surfaces in the kitchen.

Table 2-5 – Typical Efficacy of Luminairies

Light Source	Type	Rated Lamp (Watts)	Typical Efficacy (Lumens / Watt)[1]
Incandescent	Standard	40 - 100	14 - 18
Incandescent	Halogen	40 - 250	20[2]
Incandescent	Halogen IR	See footnote [3]	Up to 30
Fluorescent (Lamp/ Ballast Systems)[4]	Full-Size, 4' Long	32 - 40	69 - 91
	U-Shaped T-8 Bipin	16 - 31	78 - 90
	Compact Fluorescent	5 - 9	26 - 38
	Compact Fluorescent	13 +	42 - 58
Metal Halide	Metal Halide	32 - 175	50 - 90
High Pressure Sodium	White High Pressure Sodium	35 - 100	36 - 55

1 Includes power consumed by ballasts where applicable.

2 Halogen capsule incandescent lamps may be the most efficient light source for highlighting applications. Most halogen lamps are designed to produce a beam of directed light. Manufacturer's data typically list the "candlepower" intensity of that beam, rather than lumens (lumens measure total light output in all directions).

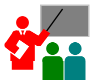
3 A new technology using infrared reflecting films on the halogen capsules has increased output up to 30 lumens/watt for some high wattage lamps.

4 Efficacy of fluorescent lighting varies depending on lamp and ballast types.

Example 2-9 – Lighting Requirements for Kitchen

Question

Would one fluorescent light in a kitchen, installed over the sink or under one cabinet, meet the "general lighting" requirements?



Answer

No. The general lighting must evenly light the entire kitchen. Two *examples* of acceptable lighting configurations are (1) fluorescent lighting (or other light source with at least 40-lumens/watt) around the perimeter of the kitchen (under or over cabinets), or (2) a fluorescent in the center of the kitchen.

Example 2-10 – Light Sources, Other than Fluorescents

Question

If a customer asks me not to install fluorescent lights in their home, are there any other light sources I can use to meet the kitchen lighting requirements?

Answer

Yes, although they may not be readily available, there are products other than fluorescent that meet the lighting requirements of the standards, §150(k). The two criteria for the kitchen and bathroom general lighting are (1) a lamp with an efficacy of 40 lumens/watt or more, and (2) the fixtures cannot contain a medium base incandescent lamp socket. Table 2-2 indicates the typical lumens/watt of several common products, some of which meet the required lumens/watt. Specifications from a product's manufacturer can also be used to verify that a product has at least 40 lumens/watt.

Example 2-11 – Energy-efficient Kitchen Lighting, General

Question

I want to design and provide an energy efficient kitchen. I especially want the lighting design to provide an aesthetically pleasing appearance, sufficient light for basic kitchen tasks, and be energy efficient while also complying with the Energy Efficiency Standards. What is the recommended practice for achieving this goal?

Answer

It is *recommended* that the builder use one of the following four ways to show compliance:

1. Design and install only high-efficacy luminaires in the kitchen. This scenario meets the code requirement in the most straightforward manner. When kitchen lighting includes both high-efficacy sources and low-efficacy sources, the design may not meet these requirements. The second through fourth ways of showing compliance apply to kitchens with both high- and low-efficacy sources.
2. Provide at least 1.2 Watts per square foot (total square feet of the accessible kitchen floor and countertop areas) of light from high-efficacy sources, and ensure that, in the judgment of the building department plan checker, the lamps in those fixtures produce a substantially uniform pattern of lighting on kitchen work surfaces (please note that this is not a code requirement but a recommendation).
3. Make sure that at least 50 percent of the kitchen lighting wattage is high-efficacy, and that, in the judgment of the building department plan checker, the lamps in those fixtures produce a substantially uniform pattern of lighting on kitchen work surfaces (please note that this is not a code requirement but a recommendation).
4. If you wish to be certain you have provided an "energy efficient kitchen…an aesthetically pleasing appearance…sufficient light for basic kitchen tasks…while also complying with the Energy Efficiency Standards," it is recommended that you use the same procedures used by professional lighting designers (again, the intent of this recommendation is not that these procedures become a standard part of builder submittals, but rather that they are used to provide the best possible solutions for builders who wish to provide high quality lighting designs).

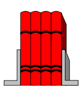
These procedures account for the characteristics of the room and the design and location of the specific high-efficacy luminaires that will be installed as the best method to determine if there is both sufficient and uniform light. A recognized lighting authority, the Illuminating Engineers Society (IES), provides guidelines for good lighting design in their Lighting Handbook, Reference & Application, 10th Edition.

IES guidelines recommend that at least 30 footcandles of light be provided for seeing tasks in kitchens. To clearly demonstrate compliance with the Standards to a building department, the builder may provide a lighting layout design that includes a point-by-point illuminance grid for the high-efficacy lighting. To do this properly, this grid must account for the room geometry, fixture placement, coefficient of utilization (CU) of the fixtures, lamp lumens, lamp lumen depreciation, and reflectivity of all of the surfaces in the kitchen. Uniform lighting assures that the minimum amount of light is available on all the work surfaces used in meal preparation and cleanup. Although the design should achieve 30 footcandles on most counter-height, horizontal work surfaces, there may be a few work-surfaces where the lighting levels fall below this value and the fronts of kitchen cabinets may also be below this value. Even in these locations, the lighting level provided by the high-efficacy source should not fall below the IES-recommended lower value for non-critical seeing tasks of 20 footcandles. Parts of counters that are not work surfaces, such as a corner underneath a cabinet, may have a lighting level below 20 footcandles and still meet the requirements of the standard, because meal preparation is unlikely to occur in those areas.

Manufacturers and lighting fixture representatives can often provide such a grid for a specified design. Electrical engineers who do lighting designs and professional lighting designers also often provide designs with a point-by-point illuminance grid.

The plans should identify the type of luminaire and maximum Underwriters Laboratory (UL)-rated lamp watts for each luminaire and should include dimensions and tolerances of each luminaire so that the installer, plan checker, and field inspector can all determine when the lighting installation matches the plan checker's judgment. When calculating the kitchen lighting wattage, the builder should be certain to use the maximum UL-rated wattage for each fixture.

Bathroom Lighting



§150(k)2 - 3

2. Each room containing a shower or bathtub shall have at least one luminaire with lamp(s) with an efficacy of 40 lumens per watt or greater. If there is more than one luminaire in the room, the high efficacy luminaire shall be switched at an entrance to the room.

ALTERNATIVE to Section 150(k)2.: A high efficacy luminaire need not be installed in a bathroom if:

A. A luminaire with lamps with an efficacy of 40 lumens per watt or greater is installed in a utility room, laundry room, or garage; and

B. All luminaires permanently mounted to the residence providing outdoor lighting shall be installed with the following characteristics:

(1) Luminaires with lamps with 40 lumens per watt or greater; or

(2) Luminaires with lamps with an efficacy of less than 40 lumens per watt shall be equipped with a motion sensor.

***Note:** When using this alternative for multiple bathrooms, after complying with B. for the first bathroom, each additional bathroom in which a high efficacy luminaire is not installed must comply with A. alone.*

3. Luminaires installed to meet the 40 lumens per watt requirements of Section 150(k) 1. or 2. shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.

Each room with a shower or bathtub must have at least one luminaire with lamps with an efficacy of at least 40 lumens/watt.

If there is more than one luminaire in the room, the high-efficacy luminaire must be switched at an entrance to the room.

As an alternative, both of the following are required:

1. A luminaire with 40 lumens/watt lamps must be installed in another room with utilitarian functions such as a laundry room, utility room or garage; and

2. All permanently mounted outside lighting must either be at least 40 lumens/watt or equipped with a motion sensor.

When using this alternative for two or more rooms with showers or bathtubs, compliance with item 1. above is sufficient for the second or third rooms since the outside lighting is already in compliance with item 2 above.

Luminaires installed to meet the 40 lumens/watt requirements cannot contain medium base incandescent lamp sockets, and must be on separate switches from incandescent lighting.

Incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with §150(k)4 (see below).

Installing energy-efficient lamps and fixtures can reduce lighting energy costs without sacrificing the quality or quantity of light available. As indicated in Table 2-2, a 40 watt standard fluorescent lamp is over four times as efficient as a 100 watt standard incandescent lamp.

Each room with a shower or bathtub (no requirement in a half-bath) must have at least one luminaire with lamps with an efficacy of at least 40 lumens/watt, which may be fluorescent or another efficient technology (see Table 2-2 above).

When there is more than one luminaire in the room, the high-efficacy luminaire (greater than or equal to 40 lumens/watt) must be switched at an entrance to the room.

As an alternative, both of the following are required:

1. A luminaire with 40 lumens/watt lamps must be installed in a laundry room, utility room or garage; and
2. All permanently mounted outside lighting must either be at least 40 lumens/watt or equipped with a motion sensor.

Luminaires installed to meet the 40 lumens/watt requirements cannot contain medium base incandescent lamp sockets, and must be on separate switches from incandescent lighting.

Incandescent lighting fixtures recessed into insulated ceilings must be IC-rated in compliance with §150(k)4 (see Example 2-13).

Example 2-12 – No Fluorescent Lights in Bathroom and Kitchen

Question

If a customer asks me not to install fluorescent lights in their home, are there any other light sources I can use to meet the bathroom and kitchen lighting requirements?

Answer

Yes, although they may not be readily available, there are products other than fluorescent that meet the lighting requirements of the standards, §150(k). The two criteria for the kitchen and bathroom general lighting are (1) a lamp with an efficacy of 40 lumens/watt or more, and (2) the fixtures cannot contain a medium base incandescent lamp socket. Table 2-5 indicates the typical lumens/watt of several common products, some of which meet the required lumens/watt. Specifications from a product's manufacturer can also be used to verify that a product has at least 40 lumens/watt.

I. Plan Check Guides and Inspection Checklists

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-1: CERTIFICATE OF COMPLIANCE(part 1 of 2)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
GENERAL		
	DATE: Verify version of Energy Efficiency Standards that apply	2.1.1 Table 1-1
GENERAL INFORMATION		
	BUILDING CONDITIONED FLOOR AREA	2.1.2 3.3.1A
	CLIMATE ZONE	APPENDIX C 3.3.1A
	BUILDING TYPE: Verify Occupancy Group(s) and if Residential determine whether NonRes or Res Standards apply.	2.1.1A 2.1.2B 3.3.1A
	PHASE OF CONSTRUCTION	
	NEW CONSTRUCTION	2.2.2 3.3.1A
	ADDITION	2.2.5 3.3.1A
	ALTERATION	2.2.4 3.3.1A
	UNCONDITIONED	2.2.1 3.3.1A
	METHOD OF ENVELOPE COMPLIANCE	
	COMPONENT	3.2.2 3.1.1A
	OVERALL ENVELOPE	3.2.3 3.1.1A
	PERFORMANCE	3.2.4 3.1.1B 3.3.1A
STATEMENT OF COMPLIANCE		
	CIVIL ENGINEER, MECHANICAL ENGINEER, ELECTRICAL ENGINEER, OR ARCHITECT. CONTRACTOR DESIGNING WORK CONTRACTED TO PERFORM OTHERWISE EXEMPT: APPLICANT TO STATE REASON FOR EXEMPTION	3.3.1
ENVELOPE MANDATORY MEASURES		
	INDICATE LOCATION ON PLANS OF NOTE BLOCK FOR MANDATORY MEASURES.	3.2.1 3.3.1A
	DOORS, WINDOWS, SKYLIGHT	3.2.1A 3.3.1A
	JOINTS AND OPENINGS	3.2.1B 3.3.1A
	INSULATION MATERIALS	3.2.1C 3.3.1A
	DEMISING WALL INSULATION	3.2.1D 3.3.1A

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-1: CERTIFICATE OF COMPLIANCE(part 2 of 2)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OPAQUE SURFACES		
	SURFACE TYPE (Name to match Opaque Surfaces on attached forms)	3.3.1B
	CONSTRUCTION TYPE	3.3.1B
	LOCATION/COMMENTS	3.3.1B
	AREA	3.3.1B
	U-VAL	3.3.1B
	AZM	3.3.1B
	TILT	3.3.1B
	SOLAR GAINS	3.3.1B
	FORM 3 REFERENCE	3.3.1B
	LOCATION/COMMENTS	3.3.1B
FENESTRATION SURFACES		
	COMPONENT (Name to match Windows on attached forms. See definition of SLOPE in Section 3.1.2A	3.1.2B
	FRAME TYPE	3.1.2B
	EXTERIOR SHADE?	3.1.2B
	OVERHANG CREDIT	3.1.2B
	GLAZING TYPE	3.1.2B
EXTERIOR SHADING		
	FENESTRATION #	3.3.1B
	EXTERIOR TYPE	3.3.1B
	SHGC	3.3.1B
	WINDOWS	3.3.1B
	Hgt.	3.3.1B
	Width	3.3.1B
	OVERHANG	3.3.1B
	Len.	3.3.1B
	Hgt.	3.3.1B
	LExt.	3.3.1B
	RExt	3.3.1B
	LEFT FIN	3.3.1B
	Dist.	3.3.1B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-1: CERTIFICATE OF COMPLIANCE(PART 2 OF 2) (CONT.)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
	Len.	3.3.1B
	Hgt.	3.3.1B
	RIGHT FIN	3.3.1B
	Dist.	3.3.1B
	Len.	3.3.1B
	Hgt.	3.3.1B
	NOTES TO FIELD	3.3.1B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: ENVELOPE COMPONENT METHOD

Note: There are two (2) methods of prescriptive compliance for the envelope requirements; the Envelope Component Method and the Overall Envelope Method. For a brief description of each of these methods refer to Section 3.1.1 A. Understanding of the "Surface Definitions" is necessary to proceed with plan checking; Refer to Section 3.1.2 A.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
WINDOW AREA CALCULATION SKYLIGHT AREA CALCULATION		
	GROSS WALL AREA(GWA) (Note: The sum of the window area, door area, and exterior wall area.)	3.1.2A 3.3.2A
	DISPLAY PERIMETER(DP)(See Definition Display Perimeter)	3.3.2A
	MAXIMUM ALLOWABLE WINDOW AREA	3.2.2E 3.3.2A
	PROPOSED WINDOW AREA(See Definition Window Area)	3.1.2A 3.3.2A
	ATRIUM HEIGHT(See Definition Atrium)	3.1.2A 3.2.2F 3.3.2B
	Allowed %	3.2.2F 3.3.2B
	GR. ROOF AREA(See Definition Gross Exterior Roof Area) (Note: The sum of the Skylight area and the exterior roof/ceiling)	3.1.2A 3.3.2B
	ALLOW. SKY. AREA	3.2.2F 3.3.2B
	ACTUAL SKY. AREA(See Definition Skylight)	3.1.2A 3.3.2B
OPAQUE SURFACES		
	ASSEMBLY NAME	ENV-1 3.3.4A 3.3.6A 3.3.2C
	TYPE	3.2.2A 3.3.3B 3.2.2C 3.2.2D
	HEAT CAPACITY > or =7.0	3.2.2B APP A:FORM ENV-3 3.2.2C
	INSULATION R-VALUE	
	WALL, FLOOR, SOFFIT WITH HC <7.0 AND ALL ROOF/CEILING	3.2.2A 3.2.2B 3.2.2C 3.2.2D
	PROPOSED(See Definition Insulation R-Value)	
	MIN. ALLOWED	
	Nonresidential Buildings	Standards Table 1-H
	High-rise Residential Bldgs and Guest Rms of Hotel/Motel Bldgs.	Standards Table 1-I
	ASSEMBLY U-VALUE	
	PROPOSED	APPENDIX A:FORM ENV-3
	WOOD FRAME	3.1.2D
	METAL FRAME	3.1.2E
	MASONRY	3.1.2F
	TABLE VALUES? (if no, form ENV-3 is required)	APPENDIX B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: ENVELOPE COMPONENT METHOD

Note: There are two (2) methods of prescriptive compliance for the envelope requirements; the Envelope Component Method and the Overall Envelope Method. For a brief description of each of these methods refer to Section 3.1.1 A. Understanding of the "Surface Definitions" is necessary to proceed with plan checking; Refer to Section 3.1.2 A.

CATEGORY	**CONSERVATION MEASURE**	***REFERENCE***
OPAQUE SURFACES		
	MAX ALLOWED	
	Nonresidential Buildings	Standards Table 1-H
	High-rise Residential Bldgs and Guest Rms of Hotel/Motel Bldgs.	Standards Table 1-I

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: ENVELOPE COMPONENT METHOD

Note: There are two (2) methods of prescriptive compliance for the envelope requirements; the Envelope Component Method and the Overall Envelope Method. For a brief description of each of these methods refer to Section 3.1.1 A. Understanding of the "Surface Definitions" is necessary to proceed with plan checking; Refer to Section 3.1.2 A.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
WINDOWS		
	WINDOW NAME From ENV-1	
	ORIENTATION See Definition Orientation	3.1.2A 3.3.2D
	U-VALUE	3.1.2H 3.3.2D
	PROPOSED (RSHG)	3.2.2E 3.3.2D
	ALLOWED RSHG	3.2.2E 3.3.2D
	# OF PANES	3.3.2D
	OVERHANG	3.1.2J 3.3.2D
	PROPOSED RSHG	3.1.2J 3.3.2D
	Nonresidential Buildings	Standards Table 1-H
	High-rise Residential Bldgs and Guest Rooms of Hotel/Motel Bldgs.	Standards Table 1-I
	ALLOW. RSHG	3.3.2d
SKYLIGHTS		
	SKYLIGHT NAME From ENV-1	
	GLAZING	3.2.2F 3.3.2E
	Translucent	Table 3-20 3.3.2E
	Transparent	Table 3-20 3.3.2E
	NO. OF PANES	3.3.2E 3.3.2e
	U-VALUE	3.1.2H 3.3.2E
	PROPOSED	3.1.2H 3.3.2E
	ALLOWED	3.2.2F 3.3.2E
	Nonresidential Buildings	Standards Table 1-H
	High-rise Residential Bldgs and Guest Rooms of Hotel/Motel Bldgs.	Standards Table 1-I
	SOLAR HEAT GAIN COEFFICIENT	3.3.2E
	PROPOSED	3.1.2J 3.3.2E
	ALLOWED	3.3.2E
	Nonresidential Buildings	Standards Table 1-H

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: ENVELOPE COMPONENT METHOD(CONT.)

Note: There are two (2) methods of prescriptive compliance for the envelope requirements; the Envelope Component Method and the Overall Envelope Method. For a brief description of each of these methods refer to Section 3.1.1 A. Understanding of the "Surface Definitions" is necessary to proceed with plan checking; Refer to Section 3.1.2 A.

CATEGORY	**CONSERVATION MEASURE**	*REFERENCE*
SKYLIGHTS		
	High-rise Residential Bldgs and Guest Rooms of Hotel/Motel Bldgs.	Standards Table 1-I

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 1 OF 5

Note: There are two (2) methods of prescriptive compliance for the envelope requirements; the Envelope Component Method and the Overall Envelope Method. For a brief description of each of these methods refer to Section 3.1.1 A. Understanding of the "Surface Definitions" is necessary to proceed with plan checking; Refer to Section 3.1.2 A.

This calculation is performed to determine if a Window Adjustment Factor or Skylight Adjustment Factor is necessary. If they are found not to be necessary Part 4 of 5 will not be submitted.

Test: If the proposed window area is greater than the larger of the Display Perimeter or 40% of the GROSS exterior wall area:

WINDOW ADJUSTMENT FACTOR = MAXIMUM AREA / PROPOSED AREA

Test: If the proposed window area is less than 10% of the GROSS exterior wall area:

WINDOW ADJUSTMENT FACTOR = MINIMUM AREA / PROPOSED AREA

Test: If the proposed skylight area is greater than the allowed skylight area:

SKYLIGHT ADJUSTMENT FACTOR = ALLOWED SKYLIGHT AREA / PROPOSED

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
WINDOW AREA TEST		
	DISPLAY PERIMETER (DP) See Definition Display Perimeter.	3.1.2A 3.3.3A
	GROSS EXTERIOR WALL AREA See Definition Gross Exterior Wall Area (Note: The sum of the window area, door area, exterior wall area, and roof / ceiling area)	3.1.2A 3.3.3A
	PROPOSED WINDOW AREA	3.3.3A
SKYLIGHT AREA TEST		
	ATRIUM HEIGHT See Definition Atrium	3.1.2A
	STANDARD %	3.3.3A
	GROSS ROOF AREA See definition Gross Exterior Roof Area. (Note: The sum of Skylight and Roof / Ceiling Area.)	3.1.2A 3.3.3A
	STANDARD SKYLIGHT AREA	3.3.3A
	PROPOSED SKYLIGHT AREA	3.3.3A

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 2 OF 5

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT LOSS		
	WALLS	
	PROPOSED ASSEMBLY NAME	From ENV-1 3.3.3B
	PROPOSED AREA See definition Exterior Wall Area(Area of opaque exterior surface of exterior walls. Does not include windows or doors.)	3.1.2A 3.3.3B
	PROPOSED HEAT CAPACITY	3.3.3B 3.1.2H
	PROPOSED U-VALUE	3..1.2C FORM ENV-3 3.3.3B
	WOOD FRAME	3.1.2D 3.3.3B
	METAL FRAME	3.1.2E 3.3.3B
	MASONRY	3.1.2F 3.3.3B
	TABLE VALUES	3.3.3B
	PROPOSED UA	3.2.3A 3.3.3B
	STANDARD AREA (ADJUSTED) If window Adjustment Factor is required from column G, Part 5 of 5.	3.1.2A 3.2.3A 3.3.3B
	STANDARD U-VALUE: Nonresidential Buildings	Standards Table 1-H
	STANDARD U-VALUE: High-rise Residential Bldgs and Guest rooms of Hotel / Motel Bldgs.	Standards Table 1-I
	STANDARD UA	3.2.3B 3.3.3B
	ROOFS / CEILINGS	
	PROPOSED ASSEMBLY NAME	From ENV-1 3.3.3B
	AREA: See definition Exterior Roof / Ceiling. Note: Area of opaque exterior surface of the roof / ceiling. Does not include skylights or doors.	3.1.2A 3.3.3B
	PROPOSED HEAT CAPACITY	3.3.3B 3.1.2H
	PROPOSED U-VALUE	3.1.2A Form ENV-3 3.3.3B
	WOOD FRAME	3.1.2D
	METAL FRAME	3.1.2E
	MASONRY	3.1.2F
	TABLE VALUES	3.3.3B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 2 OF 5(cont.)

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT LOSS		
	ROOFS / CEILINGS	
	PROPOSED UA	3.1.2A 3.3.3B
	STANDARD AREA (ADJUSTED) If Skylight Adjustment Factor is required from Column G.	3.1.2A 3.2.3A 3.3.3B
	STANDARD U-VALUE: Nonresidential Buildings	Standards Table 1-H 3.3.3B
	STANDARD U-VALUE: High-rise Residential Bldgs and Guest Rooms of Hotel / Motel Bldgs.	Standards Table 1-I 3.3.3B
	STANDARD UA	3.2.3A 3.3.3B
	FLOORS / SOFFITS	
	PROPOSED ASSEMBLY NAME	From ENV-1 3.3.3B
	AREA: See definition Exterior Roof / Ceiling. Note: Area of opaque exterior surface of the roof / ceiling. Does not include skylights or doors.	3.3.3B
	PROPOSED HEAT CAPACITY	3.3.3B 3.1.2H
	PROPOSED U-VALUE	3.1.2C 3.3.3B FORM ENV-3
	WOOD FRAME	3.1.2D
	METAL FRAME	3.1.2E
	MASONRY	3.1.2F
	TABLE VALUES	3.3.3B
	PROPOSED UA	3.2.3A 3.3.3B
	STANDARD AREA (ADJUSTED)	3.3.3B
	STANDARD U-VALUE: Nonresidential Buildings	Standards Table 1-H 3.3.3B
	STANDARD U-VALUE: High-rise Residential Bldgs and Guest Rooms of Hotel / Motel Bldgs.	Standards Table 1-I 3.3.3B
	STANDARD UA	3.2.3A 3.3.3B
	WINDOWS	
	PROPOSED ASSEMBLY NAME	From ENV-1 3.3.3B
	# OF PANES	3.3.3B
	AREA: See definition Window Area	3.3.3B
	PROPOSED HEAT CAPACITY	3.3.3B 3.1.2H

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 2 OF 5(cont.)

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT LOSS		
	WINDOWS	
	PROPOSED U-VALUE	3.1.2C 3.3.3B
	NON-METAL FRAME	
	METAL FRAME	
	TABLE VALUES	3.3.3B
	PROPOSED UA	3.2.3A 3.3.3B
	STANDARD AREA (ADJUSTED)	3.1.2A 3.3.3B
	STANDARD U-VALUE: Nonresidential Buildings	Standards Table 1-H
	STANDARD U-VALUE: High-rise Residential Bldgs and Guest Rooms of Hotel / Motel Bldgs.	Standards Table 1-I 3.3.3B 3.3.3B
	STANDARD UA	3.3.3B
	SKYLIGHTS	
	PROPOSED ASSEMBLY NAME	From ENV-1 3.3.3B
	# OF PANES	3.3.3B
	AREA: See definition Skylight Area	3.3.3B
	PROPOSED HEAT CAPACITY	3.3.3B 3.1.2H
	PROPOSED U-VALUE	3.1.2C 3.3.3B
	NON-METAL FRAME	
	METAL FRAME	
	TABLE VALUES	3.3.3B
	PROPOSED UA	3.2.3A 3.3.3B
	STANDARD AREA (ADJUSTED)	3.1.2A 3.3.3B
	STANDARD U-VALUE: Nonresidential Buildings	Standards Table 1-H
	STANDARD U-VALUE: High-rise Residential Bldgs and Guest Rooms of Hotel / Motel Bldgs.	Standards Table 1-I 3.3.3B 3.3.3B
	STANDARD UA	3.3.3B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 3 OF 5

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT GAIN FROM CONDUCTION		
	WALLS	
	ASSEMBLY NAME	3.3.3C
	PROPOSED AREA	3.3.3C
	PROPOSED TEMP-FACTOR	3.3.3C Table 3-22 Standards Table 1-J
	PROPOSED HEAT CAPACITY	3.3.3C 3.1.2H
	PROPOSED U-VALUE	3.3.3C Appendix B
	TABLE VALUES?	3.3.3C Table B-7
	PROPOSED HEAT GAIN Q	3.3.3C
	STANDARD AREA (ADJUSTED)	3.3.3C
	STANDARD U-VALUE	3.3.3C Tables 3-20, 3-21
	STANDARD TEMP-FACTOR	3.3.3C
	STANDARD HEAT GAIN Q	3.3.3C
	ROOFS / CEILINGS	
	ASSEMBLY NAME	3.3.3C
	PROPOSED AREA	3.3.3C
	PROPOSED TEMP-FACTOR	3.3.3C Table 3-22 Standards Table 1-J
	PROPOSED HEAT CAPACITY	3.3.3C 3.1.2H
	PROPOSED U-VALUE	3.3.3C Appendix B
	TABLE VALUES?	3.3.3C Table B-7
	PROPOSED HEAT GAIN Q	3.3.3C
	STANDARD AREA (ADJUSTED)	3.3.3C
	STANDARD U-VALUE	3.3.3C Tables 3-20, 3-21
	STANDARD TEMP-FACTOR	3.3.3C
	STANDARD HEAT GAIN Q	3.3.3C
	FLOORS / SOFFITS	
	ASSEMBLY NAME	3.3.3C
	PROPOSED AREA	3.3.3C
	PROPOSED TEMP-FACTOR	3.3.3C Table 3-22 Standards Table 1-J

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 3 OF 5(cont.)

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT GAIN FROM CONDUCTION		
	FLOORS / SOFFITS	
	PROPOSED HEAT CAPACITY	3.3.3C 3.1.2H
	PROPOSED U-VALUE	3.3.3C Appendix B
	TABLE VALUES?	3.3.3C Table B-7
	PROPOSED HEAT GAIN Q	3.3.3C
	STANDARD AREA (ADJUSTED)	3.3.3C
	STANDARD U-VALUE	3.3.3C Tables 3-20, 3-21
	STANDARD TEMP-FACTOR	3.3.3C
	STANDARD HEAT GAIN Q	3.3.3C
	WINDOWS	
	ASSEMBLY NAME	3.3.3C
	PROPOSED AREA	3.3.3C
	PROPOSED TEMP-FACTOR	3.3.3C Table 3-22 Standards Table 1-J
	PROPOSED HEAT CAPACITY	3.3.3C 3.1.2H
	PROPOSED U-VALUE	3.3.3C Appendix B
	TABLE VALUES?	3.3.3C Table B-7
	PROPOSED HEAT GAIN Q	3.3.3C
	STANDARD AREA (ADJUSTED)	3.3.3C
	STANDARD U-VALUE	3.3.3C Tables 3-20, 3-21
	STANDARD TEMP-FACTOR	3.3.3C
	STANDARD HEAT GAIN Q	3.3.3C
	SKYLIGHTS	
	ASSEMBLY NAME	3.3.3C
	PROPOSED AREA	3.3.3C
	PROPOSED TEMP-FACTOR	3.3.3C Table 3-22 Standards Table 1-J
	PROPOSED HEAT CAPACITY	3.3.3C 3.1.2H
	PROPOSED U-VALUE	3.3.3C Appendix B
	TABLE VALUES?	3.3.3C Table B-7
	PROPOSED HEAT GAIN Q	3.3.3C
	STANDARD AREA (ADJUSTED)	3.3.3C

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 3 OF 5(cont.)

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT GAIN FROM CONDUCTION		
	STANDARD U-VALUE	3.3.3C Tables 3-20, 3-21
	STANDARD TEMP-FACTOR	3.3.3C
	STANDARD HEAT GAIN Q	3.3.3C

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 4 OF 5

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT GAIN FROM RADIATION		
	NORTH	
	WINDOW / SKYLIGHT NAME	3.3.3D
	WEIGHTING FACTOR	3.3.3D Table 3-23 Stds Table 1-K
	PROPOSED AREA	3.3.3D 3.1.2A
	PROPOSED SOLAR FACTOR	3.3.3D Table 3-23 Stds Table 1-J
	PROPOSED SHGC	3.3.3D
	OVERHANG	
	H	3.1.2J
	V	3.1.2J
	H/V	3.3.3D
	OHF	3.3.3D
	PROPOSED HEAT GAIN Q	3.3.3D
	STANDARD AREA	3.3.3D
	STANDARD RSHG OR SHGC	3.3.3D Tables 3-20 and 3-21
	STANDARD SOLAR FACTOR	3.3.3D Table 3-22 Stds Table 1-J
	STANDARD HEAT GAIN Q	3.3.3D
	EAST	
	WINDOW / SKYLIGHT NAME	3.3.3D
	WEIGHTING FACTOR	3.3.3D Table 3-23 Stds Table 1-K
	PROPOSED AREA	3.3.3D 3.1.2A
	PROPOSED SOLAR FACTOR	3.3.3D Table 3-23 Stds Table 1-J
	PROPOSED SHGC	3.3.3D
	OVERHANG	
	H	3.1.2J
	V	3.1.2J
	H/V	3.3.3D
	OHF	3.3.3D
	PROPOSED HEAT GAIN Q	3.3.3D
	STANDARD AREA	3.3.3D

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 4 OF 5(cont.)

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT GAIN FROM RADIATION		
	EAST	
	STANDARD RSHG OR SHGC	3.3.3D Tables 3-20 and 3-21
	STANDARD SOLAR FACTOR	3.3.3D Table 3-22 Stds Table 1-J
	STANDARD HEAT GAIN Q	3.3.3D
	SOUTH	
	WINDOW / SKYLIGHT NAME	3.3.3D
	WEIGHTING FACTOR	3.3.3D Table 3-23 Stds Table 1-K
	PROPOSED AREA	3.3.3D 3.1.2A
	PROPOSED SOLAR FACTOR	3.3.3D Table 3-23 Stds Table 1-J
	PROPOSED SHGC	3.3.3D
	OVERHANG	
	H	3.1.2J
	V	3.1.2J
	H/V	3.3.3D
	OHF	3.3.3D
	PROPOSED HEAT GAIN Q	3.3.3D
	STANDARD AREA	3.3.3D
	STANDARD RSHG OR SHGC	3.3.3D Tables 3-20 and 3-21
	STANDARD SOLAR FACTOR	3.3.3D Table 3-22 Stds Table 1-J
	STANDARD HEAT GAIN Q	3.3.3D
	WEST	
	WINDOW / SKYLIGHT NAME	3.3.3D
	WEIGHTING FACTOR	3.3.3D Table 3-23 Stds Table 1-K
	PROPOSED AREA	3.3.3D 3.1.2A
	PROPOSED SOLAR FACTOR	3.3.3D Table 3-23 Stds Table 1-J
	PROPOSED SHGC	3.3.3D
	OVERHANG	
	H	3.1.2J
	V	3.1.2J
	H/V	3.3.3D
	OHF	3.3.3D
	PROPOSED HEAT GAIN Q	3.3.3D

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 4 OF 5(cont.)

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
OVERALL HEAT GAIN FROM RADIATION		
	WEST	
	STANDARD AREA	3.3.3D
	STANDARD RSHG OR SHGC	3.3.3D Tables 3-20 and 3-21
	STANDARD SOLAR FACTOR	3.3.3D Table 3-22 Stds Table 1-J
	STANDARD HEAT GAIN Q	3.3.3D
	SKYLIGHTS	
	WINDOW / SKYLIGHT NAME	3.3.3D
	WEIGHTING FACTOR	3.3.3D Table 3-23 Stds Table 1-K
	PROPOSED AREA	3.3.3D 3.1.2A
	PROPOSED SOLAR FACTOR	3.3.3D Table 3-23 Stds Table 1-J
	PROPOSED SHGC	3.3.3D
	PROPOSED HEAT GAIN Q	3.3.3D
	STANDARD AREA	3.3.3D
	STANDARD RSHG OR SHGC	3.3.3D Tables 3-20 and 3-21
	STANDARD SOLAR FACTOR	3.3.3D Table 3-22 Stds Table 1-J
	STANDARD HEAT GAIN Q	3.3.3D

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-2: OVERALL ENVELOPE METHOD - PART 5 OF 5

Note: This form is for the Overall Envelope Method to determine that the proposed design's overall heat loss, based on the installed insulation and glazing performance, are at least as good as the standard heat gain.

CATEGORY	**CONSERVATION MEASURE**	***REFERENCE***
WINDOW AREA ADJUSTMENT CALCULATIONS		
	WALL NAME	From ENV-1 3.3.3E
	ORIENTATION See definition GROSS EXTERIOR WALL AREA (Sum of Window Area, Door Area, and Exterior Wall Area)	3.1.2A 3.3.3E
	GROSS AREA	3.1.2A 3.3.3E
	DOOR AREA	3.1.2A 3.3.3E
	WINDOW ADJUSTMENT FACTOR	From Part 1 of 5 3.3.3E
	ADJUSTED WINDOW AREA(DXE)	3.2.3A 3.3.3E
	ADJUSTED WALL AREA (B-(F+C))	3.2.3A 3.3.3E
SKYLIGHT AREA ADJUSTMENT CALCULATIONS		
	ROOF NAME	From ENV-1 3.3.3E
	GROSS AREA See definition GROSS EXTERIOR ROOF AREA (Sum of Skylight Area and the Exterior roof / ceiling Area)	3.1.2A 3.3.3E
	SKYLIGHT AREA	3.1.2A 3.3.3E
	SKYLIGHT ADJUSTMENT FACTOR	From Part 1 of 5 3.3.3E
	ADJUSTED SKYLIGHT AREA (CXD)	3.2.3A 3.3.3E
	ADJUSTED ROOF AREA (B-E)	3.2.3A 3.3.3E

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-3: PROPOSED METAL FRAME ASSEMBLY

Note: This form is used to determine the Assembly U-Value for metal framed wall assemblies as an alternative to using the Metal Wall U-Value found in Table B-2, Appendix B; or to determine the Assembly U-Value for a metal framed floor, ceiling, or soffit. Refer to 3.1.2 E for description of the use of Table B-2

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
COMPONENT DESCRIPTION		
	ASSEMBLY NAME	From ENV-1 3.3.4A
	ASSEMBLY TYPE Floor. Wall, Ceiling / Roof	3.3.4A
	FRAMING MATERIAL Metal	3.3.4A
	FRAMING SIZE Nominal dimension of framing members	3.3.4A
	FRAMING SPACING 16 or 24 inches on center	3.3.4A
	INSULATION R-VALUE	3.1.2B 3.3.4A
CONSTRUCTION COMPONENTS		
	DESCRIPTION Elements of the assembly including inside/outside surface air films	3.1.2C 3.1.2E 3.3.4B Table B-1 Appendix B
	OUTSIDE/INSIDE SURFACE AIR FILM	Table 3-1 3.3.4B
	SUBTOTAL Rc Combined R-Value of Cavity	3.3.4B
	METAL FRAMING FACTOR MFF	Table 3-5 3.3.4B
	INSULATION R- VALUE	3.1.2B 3.3.4B
	Rc x MFF R-Value	3.1.2E 3.3.4B
	INSULATING SHEATHING R-Value	MFG SPECS DIRECTORY 3.3.4B
	TOTAL R-Value Rt	3.1.2E 3.3.4B
	1/Rt Assembly U-Value Insert at Column D, ENV-2, Part 2	3.1.2E 3.3.4B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-3: PROPOSED MASONRY ASSEMBLY

Note: This form is used to determine the Assembly U-Value for masonry wall assemblies as an alternate to using the Masonry Wall U-Value found in Table B-5 or B-6, Appendix B. Refer to 3.1.2F for description of the use of Table B-5 and B-6. As an alternate, it is permissible to use the method of transverse isothermal planes, ASHRAE Handbook, 1989, Fundamentals, Chapter 22 or the method described in Energy Calculations and Data, Concrete masonry Association of California and Nevada, 1986.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
COMPONENT DESCRIPTION		
	SKETCH OF ASSEMBLY	3.3.5A
	WALL ASSEMBLY NAME	From ENV-1 3.3.5A
	DESCRIPTION OF ASSEMBLY	3.3.5A
WALL R-VALUE, U-VALUE, AND HEAT CAPACITY		
	WALL UNIT THICKNESS Nominal Inches	3.3.5B
	MATERIAL TYPE	3.3.5B
	CORE TREATMENT (Grouted, Perlite, Etc.)	3.3.5B
	WALL R-VALUE Rw	Table B-5, B-6, Appendix B 3.3.5B
	WALL HEAT CAPACITY HC	Table B-5, B-6, Appendix B 3.3.5B
FURRING/INSULATION LAYER (INSIDE and/or OUTSIDE IF ANY)		
	FURRING FRAMING MATERIAL (Wood, Metal, Etc.)	3.1.2F 3.3.5C
	FURRING FRAMING SIZE Nominal Inches	3.1.2F 3.3.5C
	FURRING SPACE INSULATION Type	3.1.2F 3.3.5C
	R-VALUE	3.1.2B 3.3.5C
	EXTERIOR INSULATING LAYER	3.1.2F 3.3.5C
	R-VALUE	3.1.2B 3.3.5C
	FURRING ASSEMBLY EFFECTIVE	3.1.2F 3.3.5C
	R-VALUE	Table B-7 Appendix B 3.3.5C
	EXTERIOR INSULATING LAYER R-VALUE	MFG SPEC 3.3.5C
	INSULATING LAYER R-VALUE	3.3.5C
FURRING/INSULATION LAYER (INSIDE and/or OUTSIDE IF ANY)		
	INSULATION LAYER R-VALUE (Rf)	3.1.2F 3.3.5D
	WALL R-VALUE (Rw)	3.1.2F 3.3.5D
	WALL ASSEMBLY R-VALUE (Rf+Rw)=Rt	3.1.2F 3.3.5D
	WALL ASSEMBLY U-VALUE (1/Rt)	3.1.2F 3.3.5D
	Insert at Column D, ENV-2, Part 2	3.1.2F 3.3.5D

NONRESIDENTIAL PLAN CHECK GUIDE

FORM ENV-3: PROPOSED WOOD FRAME ASSEMBLY

Note: This form is used determine the Assembly U-Value for any construction assembly that is not a metal framed assembly or masonry wall assembly,or is not included in the tables in Appendix B. Refer to Section 3.1.2C for discussion of overall assembly U-Value.

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
COMPONENT DESCRIPTION		
	ASSEMBLY NAME	From ENV-1 3.3.6A
	ASSEMBLY TYPE Floor, Wall, or Ceiling/Roof	3.3.6A
	FRAMING MATERIAL Description of Framing Material	3.3.6A
	FRAMING SIZE Nominal Size of Framing Material	3.3.6A
	FRAMING PERCENTAGE	3.1.2D Table 3-3 3.3.6A
CONSTRUCTION COMPONENTS		
	DESCRIPTION Elements of the assembly including inside/outside surface air films	3.1.2C 3.1.2D 3.3.6B
	CAVITY R-VALUE	Table B-1 3.3.6B
	WOOD FRAME R-VALUE (Rf)	3.3.6B
	HEAT CAPACITY (HC)	3.3.6B
	WALL HEIGHT	3.3.6B
	SPECIFIC HEAT	3.3.6B
	HC (A x B)	3.3.6B
	ASSEMBLY U-VALUE	3.3.6B
	Rf R-Value of Frame Section	3.1.2D 3.3.6B
	TOTAL HC Heat Capacity of Construction Assembly	3.1.2H 3.3.6B
	(1/Rc x [1-(Fr%/100)]) + (1/Rf x Fr%/100) =	3.1.2C 3.3.6B
	ASSEMBLY U-VALUE, where:	3.1.2D 3.3.6B
	Rc = Total R-Value of framing cavity	
	Fr% = Framing Percentage	
	Rf = Total R-Value at wood frame	

NONRESIDENTIAL PLAN CHECK GUIDE

FORM MECH-1: CERTIFICATE OF COMPLIANCE

CATEGORY	CONSERVATION MEASURE	REFERENCE
GENERAL		
	DATE: Verify version of Energy Efficiency Standards that apply	2.1.1 Table 1-1 4.3.1A
GENERAL INFORMATION		
	BUILDING CONDITIONED FLOOR AREA	2.1.2
	BUILDING TYPE: Verify Occupancy Group(s) and, if Residential, determine if Nonres or res apply.	2.1.1A 2.1.2B 4.3.1B
	PHASE OF CONSTRUCTION	
	NEW CONSTRUCTION	2.2.6
	ADDITION	2.2.5
	ALTERATION	2.2.4
	METHOD OF COMPLIANCE	4.1.1
	PRESCRIPTIVE	4.1.1 4.2.2
	PERFORMANCE	4.1.1 4.2.3
	PROOF OF ENVELOPE COMPLIANCE	
	PREVIOUS ENVELOPE PERMIT	
	ENVELOPE COMPLIANCE ATTACHED	
STATEMENT OF COMPLIANCE		
	CIVIL ENGINEER, MECHANICAL ENGINEER, ELECTRICAL ENGINEER, OR ARCHITECT	4.3.1C
	CONTRACTOR DESIGNING WORK CONTRACTED TO PERFORM	4.3.1C
	OTHERWISE EXEMPT: APPLICANT TO STATE REASON FOR EXEMPTION.	4.3.1C
MECHANICAL MANDATORY MEASURES		
	MANDATORY MEASURES	4.1.1 4.2.1 4.3.1D

NONRESIDENTIAL PLAN CHECK GUIDE

FORM MECH-1: CERTIFICATE OF COMPLIANCE(cont.)

CATEGORY	**CONSERVATION MEASURE**	*REFERENCE*
SYSTEM FEATURES		
	TIME CONTROLS	4.2.1G 4.2.1H 4.3.1E
	SETBACK CONTROLS	4.2.1G 4.2.1H 4.3.1E
	ISOLATION ZONES	4.2.1G 4.2.1H 4.3.1E
	HEAT PUMP THERMOSTAT	4.2.4A.9 4.2.4B.10 4.3.1E
	ELECTRIC HEAT	4.2.2H 4.2.4A.6 4.3.1E
	FAN CONTROL	4.2.2C PLANS 4.3.1E
	VAV MINIMUM POSITION CONTROL	4.2.4B 4.2.4C 4.2.4D 4.2.4E 4.3.1E PLANS
	SIMULTANEOUS HEAT / COOL	4.2.2D.3 4.3.1E
	HEAT SUPPLY RESET	4.2.4D.10 4.3.1E
	COOL SUPPLY RESET	4.2.4D.10 4.3.1E
	VENTILATION	4.2.1F 4.3.1E
	OUTDOOR DAMPER CONTROL	4.2.1F 4.3.2D.12 4.3.1E
	ECONOMIZER TYPE	4.1.2G 4.3.1E
	DESIGN AIR CFM	4.2.1F 4.3.1E
	HEATING EQUIPMENT	4.3.1E
	TYPE	4.2.1 4.3.1E
	HIGH EFFICIENCY	4.3.1E
	MAKE AND MODEL NUMBER	4.3.1E
	COOLING EQUIPMENT TYPE	4.3.1E
	PIPE INSULATION REQUIRED?	4.3.1E
	PIPE TYPE	4.2.1I
	HEATING DUCT LOCATION	4.3.1E
	COOLING DUCT LOCATION	4.3.1E
	DUCT TAPE ALLOWED?	4.2.1J

NONRESIDENTIAL PLAN CHECK GUIDE

FORM MECH-2: MECHANICAL EQUIPMENT SUMMARY (PART 1 OF 2)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
CHILLER AND TOWER SUMMARY		
	EQUIPMENT NAME	4.3.2A
	EQUIPMENT TYPE	4.3.2A
	QTY	4.3.2A
	EFFICIENCY	Table B-9
	TONS	4.3.2A
	PUMPS TOTAL QTY	4.3.2A
	PUMPS GPM	4.3.2A
	PUMPS BHP	4.3.2A
	PUMPS MOTOR EFF.	Table B-8
	PUMPS DRIVE EFF.	4.3.2A
	PUMPS PUMP CONTROL	4.3.2A
DHW / BOILER SUMMARY		
	SYSTEM NAME	4.3.2B
	SYSTEM TYPE	4.3.2B
	DISTRIBUTION TYPE	4.3.2B
	QTY.	4.3.2B
	RATED INPUT	4.3.2B
	VOL.(GALS.)	4.3.2B
	ENERGY FACTOR OR RECOVERY EFFICIENCY	4.3.2B
	STANDBY LOSS OR PILOT	4.3.2B
	TANK INSUL.	4.3.2B
CENTRAL SYSTEM RATINGS		
	SYSTEM NAME	4.3.2C
	SYSTEM TYPE	4.3.2C
	QTY.	4.3.2C
	HEATING OUTPUT	4.3.2C
	HEATING AUX KW	4.3.2C
	HEATING EFFICIENCY	Table B-9
	COOLING OUTPUT	4.3.2C
	COOLING SENSIBLE	4.3.2C
	COOLING EFFICIENCY	Table B-9
	COOLING ECONOMIZER TYPE	4.3.2C

FORM MECH-2: MECHANICAL EQUIPMENT SUMMARY (PART 1 OF 2) (cont.)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
CENTRAL FAN SUMMARY		
	SYSTEM NAME	4.3.2D
	FAN TYPE	4.3.2D
	MOTOR LOCATION	4.3.2D
	SUPPLY FAN CFM	4.3.2D
	SUPPLY FAN BHP	4.2.2C
	SUPPLY FAN MOTOR EFF.	Table B-8
	SUPPLY FAN DRIVE EFF.	4.3.2D
	RETURN FAN CFM	4.3.2D
	RETURN FAN BHP	4.2.2C
	RETURN FAN MOTOR EFF.	Table B-8
	RETURN FAN DRIVE EFF.	4.3.2D

NONRESIDENTIAL PLAN CHECK GUIDE

FORM MECH-2: MECHANICAL EQUIPMENT SUMMARY (PART 2 OF 2)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
VAV SUMMARY		
	ZONE NAME	4.3.2E
	VAV SYSTEM TYPE	4.3.2E
	VAV QTY.	4.3.2E
	VAV MIN. CFM RATIO	4.3.2E
	VAV TYPE	4.3.2E
	VAV DELTA T	4.3.2E
	FAN FLOW RATIO	4.3.2E
	FAN CFM	4.3.2E
	FAN BHP	4.2.2C
	FAN MOTOR EFF.	Table B-8
	FAN DRIVE EFF.	4.3.2E
	BASEBOARD TYPE	4.3.2E
	BASEBOARD OUTPUT	4.3.2E
EXHAUST FAN SUMMARY		
	EXHAUST FAN SUMMARY	4.3.2F
	ROOM NAME	4.3.2F
	QTY.	4.3.2F
	CFM	4.3.2F
	BHP	4.2.2C
	MOTOR EFF.	Table B-8
	DRIVE EFF	4.3.2F

NONRESIDENTIAL PLAN CHECK GUIDE

FORM MECH-3: MECHANICAL VENTILATION

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
VENTILATION CALCULATIONS		
	ZONE / SYSTEM	PLANS / SPECS
	AREA BASIS	
	COND. AREA	PLANS / SPECS
	CFM / SF	ASHRAE STD 62-1989
	MIN CFM	CALCULATED
	OCCUPANCY BASIS	
	NO. OF PEOPLE	PLANS / SPECS
	CFM / PERSON	4.2.1F
	MIN CFM	CALCULATED
	REQ'D O.A.	4.3.3A
	DESIGN OUTDOOR AIR CFM	4.3.3A
	VAV MINIMUM CFM	4.3.3A
	LARGEST MIN CFM	4.3.4
	DESIGN MIN CFM	4.3.4
	TRANSFER AIR	CALCULATED 4.3.4

FORM MECH-4: MECHANICAL SIZING AND FAN POWER

CATEGORY	CONSERVATION MEASURE	REFERENCE
SIZING AND EQUIPMENT SELECTION		
	DESIGN CONDITIONS	ASHRAE
	OUTDOOR , DRY BULB TEMPERATURE	4.2.2B
	OUTDOOR , WET BULB TEMPERATURE	4.3.4A
	INDOOR, DRY BULB TEMPERATURE	APPENDIX C
	SIZING	4.2.2A 4.3.4A
	DESIGN OUTDOOR AIR	4.3.4A APPENDIX C
	ENVELOPE LOAD	4.2.2B.6 4.3.4.A
	LIGHTING	4.2.2.B.7 4.3.4A
	PEOPLE	Form MECH-4
	MISC. EQUIPMENT	ASHRAE STDS 4.3.4A
	OTHER	ASHRAE STDS 4.3.4A
	OTHER LOADS/SAFETY FACTOR	4.3.4A
	MAXIMUM ADJUSTED LOAD	4.3.4A
	INSTALLED EQUIPMENT CAPACITY	MANUF. DATA 4.3.4A
FAN POWER CONSUMPTION		
	FAN DESCRIPTION	4.2.2C 4.3.4B
	DESIGN BRAKE HORSEPOWER	MANUF. DATA
	EFFICIENCY	PLANS/SPECS 4.3.4B
	NUMBER OF FANS	PLANS/SPECS 4.3.4B
	PEAK WATTS	4.3.4B
	CFM	PLANS/SPECS 4.3.4B
	TOTALS	4.3.4B
	TOTAL FAN SYSTEM POWER DEMAND	4.3.4B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM LTG-1: CERTIFICATE OF COMPLIANCE (PART 1 OF 2)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
GENERAL		
	DATE	2.1.1 Table 1-I 5.3.1A
GENERAL INFORMATION		
	BUILDING CONDITIONED FLOOR AREA	2.1.2A 5.3.1A
	CLIMATE ZONE	APPENDIX C 5.3.1A
	BUILDING TYPE: Verify Occupancy Group(s) and if Residential determine whether NonRes or Res Standards apply.	2.1.1 2.1.2B 5.3.1A
	PHASE OF CONSTRUCTION	
	NEW CONSTRUCTION	2.2.2 5.3.1A
	ADDITION	2.2.5 5.3.1A
	ALTERATION	2.2.4 5.3.1A
	UNCONDITIONED	2.2.1 5.3.1A
	METHOD OF COMPLIANCE	5.1.1 5.3.1A
	AREA CATEGORY	5.2.2B 5.3.1A
	TAILORED	5.2.2C 5.3.1A
	PERFORMANCE	5.2.3 5.3.1A
STATEMENT OF COMPLIANCE		
	CIVIL ENGINEER, MECHANICAL ENGINEER, ELECTRICAL ENGINEER, OR ARCHITECT. CONTRACTOR DESIGNING WORK CONTRACTED TO PERFORM OTHERWISE EXEMPT: APPLICANT TO STATE REASON FOR EXEMPTION	5.3.1A B&P CODE

NONRESIDENTIAL PLAN CHECK GUIDE

FORM LTG-1: CERTIFICATE OF COMPLIANCE (PART 1 OF 2) (cont.)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
LIGHTING MANDATORY MEASURES		
	CONTROL REQUIREMENTS	5.2.1A 5.3.1A
	AREA REQUIREMENTS	5.2.1A 5.3.1A
	ROOM SWITCHING	5.2.1A 5.3.1A
	ACCESSIBILITY	5.2.1A 5.3.1A
	PUBLIC AREAS	5.2.1A 5.3.1A
	SECURITY OR EMERGENCY	5.2.1A 5.3.1A
	OTHER DEVICES	5.2.1A 5.3.1A
	BI-LEVEL SWITCHING	5.2.1B 5.3.1A
	DAYLIT AREAS	5.2.1C 5.3.1A
	EFFECTIVE APERTURE	5.2.1C 5.3.1A
	VISIBLE LIGHT TRANSMITTANCE (VLT)	5.2.1C 5.3.1A
	WELL INDEX	5.2.1C 5.3.1A
	DISPLAY LIGHTING	5.2.1E 5.3.1A
	SHUT-OFF CONTROLS	5.2.1D 5.3.1A
	EXTERIOR LIGHTS	5.2.1F 5.3.1A
	TANDEM WIRING	5.2.1G 5.3.1A
	HIGH RISE RESIDENTIAL AND HOTEL / MOTEL GUEST ROOMS	5.2.1J 5.3.1A
	KITCHEN LIGHTING	5.2.1J 5.3.1A
	BATHROOM LIGHTING	5.2.1J 5.3.1A
	GENERAL	5.2.1J 5.3.1A
	CERTIFIED AUTOMATIC LIGHTING CONTROL DEVICES	5.2.1H 5.3.1A
	AUTOMATIC TIME SWITCHES (ATS)	5.2.1H 5.3.1A
	OCCUPANCY SENSORS	5.2.1H 5.3.1A
	AUTOMATIC DAYLIGHT CONTROLS	5.2.1H 5.3.1A
	LUMEN MAINTENANCE CONTROL	5.2.1H 5.3.1A
	INTERIOR PHOTOCELL	5.2.1H 5.3.1A
	CERTIFIED BALLASTS AND LUMINAIRES	5.2.1I 5.3.1A

NONRESIDENTIAL PLAN CHECK GUIDE

FORM LTG-1: CERTIFICATE OF COMPLIANCE (PART 2 OF 2)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
INSTALLED LIGHTING SCHEDULE		
	DESCRIPTION: To identify for attached forms	Same as LTG-1 5.3.1B
	LAMPS	5.3.1B
	TYPE description	5.3.1B
	#	5.3.1B
	WATTS PER LAMP	5.3.1B 5.2.4
	BALLAST	5.3.1B
	TYPE description	5.3.1B
	#	5.3.1B
	LUMINAIRE	5.3.1B
	#	5.3.1B
	WATTS	5.3.1B
	TOTAL WATTS	5.3.1B
	I=INCANDESCENT	5.3.1B
	F=FLOURESCENT	5.3.1B
	H=HIGH INTENSITY DISCHARGE	5.3.1B
	BALLASTS	5.3.1B
	S=STANDARD MAGNETIC	Directory of Certified Ballasts
	E=ELECTRONIC HIGH FREQUENCY	Supporting documents required
	O=OTHER	Supporting documents required
MANDATORY AUTOMATIC CONTROLS		
	CONTROL LOCATION: To identify for attachment forms	5.2.1A 5.3.1B
	CONTROL IDENTIFICATION	5.2.1A 5.3.1B
	CONTROL TYPE	5.2.1A 5.3.1B
	BUILDING SHUT OFF	5.2.1A 5.3.1B
	INDIVIDUAL ROOM CONTROL	5.2.1A 5.3.1B
	CONTROL OF EXTERIOR LIGHTS	5.2.1A 5.3.1B
	SPACE CONTROLLED	5.2.1A 5.3.1B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM LTG-2: LIGHTING COMPLIANCE

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
ACTUAL LIGHTING POWER		
	LUMINAIRE NAMES	From LTG-1
	DESCRIPTION	5.3.2A
	NUMBER OF LUMINAIRES	5.3.2A
	WATTS PER LUMINAIRE	5.3.2A
	CEC DEFAULT:	CEC Directory
	Y=Data is a standard value from data references. N= Manufacturer's data sheets are LESS CONTROL CREDITS: Form LTG-3 is required.	
	TOTAL WATTS	5.3.2A
	ADJUSTED ACTUAL WATTS Must be equal to or less than the allowed Watts.	5.2.4A 5.2.4B 5.3.2A
ALLOWED LIGHTING POWER (Choose one Method)		
	COMPLETE BUILDING METHOD	5.2.2A 5.3.2B
	BUILDING CATEGORY	Table 5-3 5.3.2B
	WATTS PER SF	Table 5-3 5.3.2B
	COMPLETE BUILDING AREA	Form LTG-1 5.3.2B
	ALLOWED WATTS	watts/sf x BLDG AREA 5.3.2B
	AREA CATEGORY METHOD	5.2.2B 5.3.2B
	AREA CATEGORY	Table 5-4 5.3.2B
	WATTS PER SF	5.3.2B
	ALLOWED LIGHTING POWER	Table 5-4 5.3.2B
	AREA (SF)	5.2.2B PLANS 5.3.2B
	ALLOWED WATTS	watts/sf x AREA SF 5.3.2B
	TOTAL AREA	Form LTG-1 5.3.2B
	TOTAL WATTS	ALLOWED WATTS 5.3.2B
	TAILORED METHOD	5.2.2C 5.3.2B
	TAILORED METHOD TOTAL ALLOWED WATTS	5.3.2B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM LTG-3: LIGHTING CONTROLS CREDIT WORKSHEET

CATEGORY	CONSERVATION MEASURE	REFERENCE
WORKSHEET		
	Used for credit for lighting controls not required as mandatory measures.	
	ROOM # ZONE ID	Form LTG-1 5.3.3
	LIGHTING CONTROL DESCRIPTION	Form LTG-1 5.3.3
	OCCUPANCY SENSOR	5.1.2D 5.3.3
	DIMMING SYSTEM	5.1.2D 5.3.3
	LUMEN MAINTENANCE CONTROLS	5.1.2D 5.3.3
	TUNING	5.1.2D 5.3.3
	AUTOMATIC TIME SWITCH CONTROL DEVICE	5.1.2D 5.3.3
	COMBINED CONTROLS	5.1.2D 5.3.3
	PLANS REF. Location for details on plans.	5.3.3
	ROOM AREA SF Square footage of room or area included in control devices.	5.3.3 5.3.3
	DAYLIGHTING To be completed for daylight controls	5.3.3
	ROOM RATIO	5.3.3
	WINDOW WALL RATIO	5.2.1C 5.3.3
	SKYLIGHT / CEILING	5.2.1C 5.3.3
	GLAZING VLT	5.2.1C 5.3.3
	WATTS OF CONTROL LIGHTING Connected Watts of fixtures under control	5.3.3
	LIGHTING ADJUSTMENT FACTOR	Table 5-10 5.3.3
	CONTROL CREDIT WATTS	(Col G x Col H) 5.3.3
	BUILDING TOTAL To be entered on the LTG-2 "Less Control Credits"	5.3.3

NONRESIDENTIAL PLAN CHECK GUIDE

FORM LTG-4: TAILORED LPD SUMMARY AND WORKSHEET(part 1 of 3)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
TAILORED LPD SUMMARY		
	WATTS FOR ILLUMINANCE CATEGORIES A-D	5.2.2C 5.3.4A
	WATTS FOR ILLUMINANCE CATEGORIES E-I	Appendix B 5.3.4A
	WATTS FOR DISPLAY LIGHTING	5.2.2C 5.3.4A
	TOTAL ALLOWED WATTS	5.2.2C 5.3.4A
TAILORED LPD - ILLUMINANCE CATEGORIES A,B,C, AND D		
	ROOM NUMBER	PLANS 5.3.4A
	TASK / ACTIVITY	5.2.2C 5.3.4A
	IES ILLUM. CATEGORY	IES Handbook (Appendix B) 5.3.4A
	ROOM CAVITY RATIO	5.2.2C 5.3.4A
	FLOOR AREA	PLANS
	ALLOWED LPD	Table 5-7 5.3.4A
	ALLOWED WATTS	To Tailored LPD Summary Line 1

NONRESIDENTIAL PLAN CHECK GUIDE

FORM LTG-4: TAILORED LPD SUMMARY AND WORKSHEET (part 2 of 3)

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
TAILORED LPD - ILLUMINANCE CATEGORIES E,F,G,H,I, AND GROSS SALES		
Note: Areas adjacent to tasks	TASK / ACTIVITY	5.2.2C 5.3.4B
of Categories F,G,H, and I must be	ILLUMINANCE CATEGORY	IES Handbook (Appendix B) 5.3.4B
assigned a category between	RCR (If E) Room Cavity Ratio	5.2.2C 5.3.4B
A and D.	NOTES: Note Mounting Height or Throw Distance (Gross Sales)	5.2.2C 5.3.4B
	ALLOWED WATTS	5.2.2C 5.3.4B
	TASK AREA (sf)	PLANS 5.3.4B
	ALLOWED LPD	Table 5-7, 5-8 5.3.4B
	ALLOTTED WATTS	Task Areas Allotted LPD 5.3.4B
	DESIGN WATTS	5.3.4B
	LUMIN CODE	Form LTG-1 5.3.4B
	QTY (Number of Luminaries)	Form LTG-1 5.3.4B
	WATTS / LUMIN.	CEC Directory Table B-11 5.3.4B
	DESIGN WATTS	Qty. x watts / lumen
	ALLOWED WATTS The Smaller of Allotted Watts or Design Watts	To Tailored LPD Summary Line 2
TAILORED LPD - PUBLIC AREA DISPLAYS		
Note: Refer to definition	TASK / ACTIVITY	5.2.2C 5.3.4B
"DISPLAY", "PUBLIC AREA",	THROW DIST.	5.2.2C 5.3.4B
5.2.2C.	MOUNTING HEIGHT	5.2.2C 5.3.4B
	ALLOTTED WATTS	
	TASK AREA (sf)	PLANS
	ALLOWED LPD	Table 5-7 5.3.4B
	ALLOTTED WATTS	Task Area x Allowed LPD 5.3.4B
	DESIGN WATTS	
	LUMEN CODE	Form LTG-1 5.3.4B
	QTY (Number of luminaires)	Form LTG-1 5.3.4B
	WATTS / LUMIN	Form LTG-1 5.3.4B Table B-11
	DESIGN WATTS	Qty. x watts / lamp
	ALLOWED WATTS (The Smaller of Allotted Watts or Design)	To Tailored LPD Summary Line 3
	MAXIMUM AREA PUBLIC DISPLAYS=10% of Public Display Area	5.2.2C 5.3.4B

NONRESIDENTIAL PLAN CHECK GUIDE

FORM LTG-4: TAILORED LPD SUMMARY AND WORKSHEET (part 3 of 3)

CATEGORY	**CONSERVATION MEASURE**	***REFERENCE***
TAILORED LPD - SALES FEATURE FLOOR DISPLAYS		
Note: Refer to definition	TASK / ACTIVITY	PLANS 5.3.4C
"DISPLAY", "SALES FEATURE	THROW DIST.	5.2.2C 5.3.4C
FLOOR", 5.2.2C	MOUNTING HEIGHT	5.2.2C 5.3.4C
	ALLOTTED WATTS	
	TASK AREA (SF)	PLANS
	CAT. G LPD	Table 5-8 5.3.4C
	ALLOTTED WATTS (D x E)	Task Area x CAT.G LPD 5.3.4C
	DESIGN WATTS	
	LUMEN CODE	Form LTG-1 5.3.4C
	QTY.	Form LTG-1 5.3.4C
	WATTS / LUMEN	Form LTG-1 5.3.4C Table B-11
	DESIGN WATTS (H x I)	Qty. x watts / lamp
	ALLOWED WATTS (The smaller of Allotted watts or Design watts)	To Tailored LPD Summary Line 3
	TOTAL AREA FLOOR DISPLAYS	PLANS
	GROSS SALES FLOOR AREA. Maximum area floor displays= 10% of the gross sales floor area.	5.2.2C 5.3.4C
TAILORED LPD - SALES FEATURE WALL DISPLAYS		
	TASK / ACTIVITY	PLANS 5.3.4C
	THROW DIST.	5.2.2C 5.3.4C
	ALLOTTED WATTS	5.2.2C 5.3.4C
	TASK AREA (SF)	PLANS
	ALLOTTED WATTS (C x D)	Task Area x Allowed LPD 5.3.4C
	ALLOWED LPD	Table 5-7 5.3.4C
	LUMEN CODE	Form LTG-1 5.3.4C
	QUANTITY (No. of Lamps)	Form LTG-1 5.3.4C
	WATTS / LUMEN.	Form LTG-1 5.3.4C Table B-11
	DESIGN WATTS (G x H)	Qty. x Watts / lamp
	ALLOWED WATTS (The Smaller of Allotted watts or Design watts)	5.3.4C
	TOTAL AREA WALL DISPLAYS	PLANS
	GROSS SALES WALL AREA. Maximum area wall displays= 10% of gross sales floor area.	

FORM LTG-5: ROOM CAVITY RATIO WORKSHEET

CATEGORY	CONSERVATION MEASURE	*REFERENCE*
RECTANGULAR SPACES		
	ROOM NUMBER	5.3.5B
	TASK / ACTIVITY DESCRIPTION	5.3.5B
	ROOM LENGTH (L)	5.3.5B
	ROOM WIDTH (W)	5.3.5B
	ROOM HEIGHT (H)	5.3.5B
	ROOM CAVITY RATIO = [5 x H x(L+W) / (L x W)]	5.3.5B
NON-RECTANGULAR SPACES		
	ROOM NUMBER	5.3.5C
	TASK / ACTIVITY DESCRIPTION	5.3.5C
	ROOM AREA (A)	5.3.5C
	ROOM PERIMETER (P)	5.3.5C
	ROOM CAVITY HEIGHT (H)	5.3.5C
	ROOM CAVITY RATIO = [(2.5 x H x P) / A]	5.3.5C

NONRESIDENTIAL BUILDING ENERGY EFFICIENCY STANDARDS

INSPECTION CHECKLIST

FIELD INSPECTION GUIDELINE

NOTE: The 1998 Energy Efficiency Standards for Nonresidential Buildings apply to buildings of Occupancy Groups A, B, E, F, H, M, and S; to High Rise Residential occupancy; and to Hotel/Motel Guest Rooms. The Energy efficiency Standards govern Envelope, Mechanical Systems, and Lighting Systems.

FOUNDATION INSPECTION

CATEGORY	*FEATURE*	*CONSERVATION MEASURE*	*REFERENCE*
ORIENTATION			PLANS
STRUCTURAL:			
	BUILDING DIMENSIONS	CONDITIONED FLOOR AREA	ENV-1 GENERAL INFO
	SLAB EDGE/BASEMENT OR FOUNDATION	CERTIFIED INSULATION MATERIALS	MANDATORY MEASURE
	FOUNDATION WALL	U-VALUE OF INSULATION	ENV-1 OPAQUE
	MASS WALLS	HEAT CAPACITY	ENV-2 OPAQUE
MECHANICAL:			
	BUILDING DIMENSIONS	CONDITIONED FLOOR AREA	MECH-1 GENERAL INFO
LIGHTING:			
	BUILDING DIMENSIONS	CONDITIONED FLOOR AREA	LTG-1 GENERAL INFO

NONRESIDENTIAL BUILDING ENERGY EFFICIENCY STANDARDS

INSPECTION CHECKLIST

FIELD INSPECTION GUIDELINE

NOTE: The 1998 Energy Efficiency Standards for Nonresidential Buildings apply to buildings of Occupancy Groups A, B, E, F, H, M, and S; to High Rise Residential occupancy; and to Hotel/Motel Guest Rooms. The Energy efficiency Standards govern Envelope, Mechanical Systems, and Lighting Systems.

CONCRETE SLAB OR UNDER-FLOOR INSPECTION

CATEGORY	*FEATURE*	*CONSERVATION MEASURE*	*REFERENCE*
STRUCTURAL:			
	SLAB-EDGE/UNDER FLOOR INSULATION	CERTIFIED INSULATION	MANDATORY MEASURES
		U-VALUE OF INSULATION MATERIALS	ENV-1 OPAQUE
	FLOOR MASS	MATERIALS HEAT CAPACITY	ENV-2 OPAQUE
MECHANICAL:			
	DUCT/PIPING	LOCATION	MECH-1 PART 2
		TYPE	MECH-1 PART 2
		INSULATION R-VALUE	MECH-1 PART 2
		DUCT TAPE ALLOWED?	MECH-1 PART 2
LIGHTING:			
	CONDUIT/RACEWAY	CONTROL REQUIREMENTS	MANDATORY MEASURE
		Area requirements	
		Room switching	
		Accessibility	
		Other devices	
		Bi-level reduction illumination	
		Exterior lights	
		Display lighting	
		Shut-off controls	
		Display lighting	
		MANDATORY AUTOMATIC CONTROLS	LTG-1 PART 2
		CONTROLS FOR CREDIT	LTG-3

NONRESIDENTIAL BUILDING ENERGY EFFICIENCY STANDARDS

INSPECTION CHECKLIST

FIELD INSPECTION GUIDELINE

NOTE: The 1998 Energy Efficiency Standards for Nonresidential Buildings apply to buildings of Occupancy Groups A, B, E, F, H, M, and S; to High Rise Residential occupancy; and to Hotel/Motel Guest Rooms. The Energy efficiency Standards govern Envelope, Mechanical Systems, and Lighting Systems.

FRAME INSPECTION

CATEGORY	*FEATURE*	*CONSERVATION MEASURE*	*REFERENCE*
STRUCTURAL:			
	FENESTRATION	CERTIFICATION	MANDATORY MEASURE
		ROUGH-IN DIMENSIONS	PLANS
		ORIENTATION	PLANS
		EXTERIOR OVERHANG	ENV-1 EXTERIOR SHADING
	EXTERIOR DOORS	CAULKING	MANDATORY MEASURE
		WEATHER-STRIP	MANDATORY MEASURE
	WINDOWS	MANUFACTURED	
		Label	MANDATORY MEASURE
		U-value	ENV-1 FENESTRATION
		Solar Heat Gain Coefficient	ENV-1 FENESTRATION
		Caulking	MANDATORY MEASURE
		SITE CONSTRUCTED	
		Solar Heat Gain Coefficient	ENV-1 FENESTRATION
		Caulking	MANDATORY MEASURE
		Weather-stripping	MANDATORY MEASURE
	SKYLIGHTS	MANUFACTURED	
		Label	MANDATORY MEASURE
		U-value	ENV-1 FENESTRATION
		Solar Heat Gain Coefficient	ENV-1 FENESTRATION
		Caulking	MANDATORY MEASURE
		SITE CONSTRUCTED	
		Solar Heat Gain Coefficient	ENV-1 FENESTRATION
		Caulking	MANDATORY MEASURE
		Weather-stripping	MANDATORY MEASURE
	EXTERIOR WALLS/DEMISING	CONSTRUCTION TYPE	ENV-1 OPAQUE
	PARTITIONS	MASS/HEAT CAPACITY	ENV-2 OPAQUE
	ROOF/CEILING	CONSTRUCTION TYPE	ENV-1 OPAQUE
	ROOF/CEILING	CONSTRUCTION TYPE	ENV-1 OPAQUE

FRAME INSPECTION (CONTINUED)

CATEGORY	*FEATURE*	*CONSERVATION MEASURE*	*REFERENCE*
STRUCTURAL (CONTINUED):			
	FLOOR/SOFFIT	CONSTRUCTION TYPE	ENV-1 OPAQUE
MECHANICAL:			
	DUCT/PIPING	LOCATION	MECH-1 PART 2
		TYPE	MECH-1 PART 2
		INSULATION R-VALUE	MECH-1 PART 2
		DUCT TAPE ALLOWED	MECH-1 PART 2
	CONTROLS (WIRING FOR)	NUMBER OF SYSTEMS/ZONES	MECH-1 PART 2
		THERMOSTAT/TIME CONTROLS PER ZONE	MECH-1 PART 2
LIGHTING:			
	CONDUIT/RACEWAY	CONTROL REQUIREMENTS	MANDATORY MEASURE
		Area requirements	
		Room switching	
		Accessibility	
		Other devices	
		Bi-level reduction illumination	
		Daylight areas	
		Display lighting	
		Shut-off controls	
		Exterior lights	
		MANDATORY AUTOMATIC CONTROLS	LTG-1 PART 2
		Building shut-off	
		Individual room control	
		Control of exterior lights	
		TANDEM WIRING	
		One or three lamp luminaries	MANDATORY MEASURE
		CONTROLS FOR CREDIT	LTG-3
		Occupancy sensor	
		Dimming switch	
		Lumen maintenance controls	
		Tuning	
		Automatic time switch control	
		Combined controls	

NONRESIDENTIAL BUILDING ENERGY EFFICIENCY STANDARDS

INSPECTION CHECKLIST

FIELD INSPECTION GUIDELINE

NOTE: The 1998 Energy Efficiency Standards for Nonresidential Buildings apply to buildings of Occupancy Groups A, B, E, F, H, M, and S; to High Rise Residential occupancy; and to Hotel/Motel Guest Rooms. The Energy efficiency Standards govern Envelope, Mechanical Systems, and Lighting Systems.

INSULATION INSPECTION

CATEGORY	*FEATURE*	*CONSERVATION MEASURE*	*REFERENCE*
STRUCTURAL:			
	EXTERIOR WALLS/	CONSTRUCTION TYPE	ENV-1 OPAQUE
	DEMISING PARTITIONS	MASS/HEAT CAPACITY	ENV-2 OPAQUE
		INSULATION R-VALUE	ENV-2 OPAQUE
		CERTIFIED INSULATION MATERIALS	MANDATORY MEASURES
	ROOF/CEILING	CONSTRUCTION TYPE	ENV-1 OPAQUE
		INSULATION R-VALUE	ENV-2 OPAQUE
		CERTIFIED INSULATION MATERIALS	MANDATORY MEASURES
	FLOOR/SOFFIT	CONSTRUCTION TYPE	ENV-1 OPAQUE
		INSULATION R-VALUE	ENV-2 OPAQUE
		CERTIFIED INSULATION MATERIALS	MANDATORY MEASURES

NONRESIDENTIAL BUILDING ENERGY EFFICIENCY STANDARDS

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FINAL INSPECTION

CATEGORY	*FEATURE*	*CONSERVATION MEASURE*	*REFERENCE*
MECHANICAL:			
	SYSTEM TYPE	HEATING - MAKE/MODEL	MECH-1 SYSTEM FEATURES
		COOLING - MAKE/MODEL	MECH-1 SYSTEM FEATURES
		VENTILATION - NATURAL/MECHANICAL	MECH-1 SYSTEM FEATURES
		ECONOMIZER	MECH-1 SYSTEM FEATURES
	CONTROLS	NUMBER OF SYSTEMS/ZONES	MECH-1 PART 2
		THERMOSTAT/TIME HEATPUMP	MECH-1 PART 2
		CONTROLS PER ISOLATION ZONE	MECH-1 PART 2
LIGHTING:			
	CONTROL	AREA REQUIREMENTS	MANDATORY MEASURE
		Room switching	
		Control or occupancy sensor in each area	
		Accessibility	
		Control within sight of the controlled area	
		Other devices	
		Special devices or overrides	
		BI-LEVEL REDUCTION ILLUMINATION	MANDATORY MEASURE
		> 100sf and > 1.2 Watts/sf	
		DAYLIT AREAS	MANDATORY MEASURE
		>250sf and windows or skylights	
		Separate switching	
		DISPLAY LIGHTING	MANDATORY MEASURE
		Feature display in retail store	
		Separate switching	
		SHUT-OFF CONTROLS	MANDATORY MEASURE
		>5,000sf with automatic time switch	
		EXTERIOR LIGHTS	MANDATORY MEASURE
		Photocell or automatic time switch	

FINAL INSPECTION (CONTINUED)

CATEGORY	FEATURE	CONSERVATION MEASURE	REFERENCE
LIGHTING (CONTINUED)			
	TANDEM WIREING	ONE OR THREE LUMINAIRES	MANDATORY MEASURE
	MANDATORY AUTOMATIC BUILDING SHUT-OFF CONTROLS		LTG-1
	CONTROLS FOR CREDIT	OCCUPANCY SENSOR	LTG-3
		Time delay	
		DIMMING SYSTEM	LTG-3
		Uniform reduction to 1/2	
		Flicker free operation	
		Time delay	
		LUMIN MAINTENANCE CONTROLS	LTG-3
		Alarm	
		TUNING	LTG-3
		AUTOMATIC TIME SWITCH CONTROL DEVICE	LTG-3
		Separate programs for weekend/holidays	
		Override switching	
		Ten hour backup power	
		COMBINED CONTROLS	LTG-3
	LUMINAIRES	TYPE	LTG-1
		Incandescent	
		Florescent	
		High-intensity discharge	
		NUMBER OF LAMPS	LTG-1
		WATTS PER LAMP	LTG-1
		BALLASTS	LTG-1
		Standard magnetic	
		Electronic high frequency	
		Other	
		Number per luminaire	

J. History of the Standards and Manuals

Table J-1–History of Standards and Manuals

Date	***Set of Standards***	***Compliance***
1978	First Generation Residential (including Hotels and High-rise)	Energy Conservation Design Manual for New Residential Buildings (2/78)
1978	First Generation Nonresidential	Energy Conservation for New Nonresidential Buildings (10/77)
1983 to 1984	Second Generation Residential (excluding Hotels and High-rise)	Energy Conservation for New Residential Buildings (Fall, 1984)
1987	Second Generation Nonresidential (only Office)	Energy Efficiency Manual, Designing for Compliance (12/86)
1988	Second Generation Nonresidential (Office and Retail	Energy Efficiency Manual, Designing for Compliance (12/86)
1988	Second Generation Residential (excluding Hotels and High-rise)	Energy Conservation for New Residential Buildings (7/88)
1992	Nonresidential Standards (includes Hotels and High-rise Residential)	Nonresidential Manual for Compliance with Energy Efficiency Standards (7/92)
1992	Residential Standards (excludes Hotels and High-rise)	Residential Manual for Compliance with Energy Efficiency Standards (7/92)
1995	Nonresidential Standards (includes Hotels and High-rise Residential)	Nonresidential Manual for Compliance with Energy Efficiency Standards (7/95)
1995	Residential Standards (excludes Hotels and High-rise)	Residential Manual for Compliance with Energy Efficiency Standards (7/95)
1998	Nonresidential Standards (includes Hotels and High-rise Residential)	Nonresidential Manual for Compliance with Energy Efficiency Standards (7/98)
1998	Residential Standards (excludes Hotels and High-rise)	Residential Manual for Compliance with Energy Efficiency Standards (7/98)
2001	Energy Efficiency Standards for Residential and Nonresidential Buildings	Residential Manual for Compliance with Energy Efficiency Standards (7/01)
2001	Energy Efficiency Standards for Residential and Nonresidential Buildings	Nonresidential Manual for Compliance with Energy Efficiency Standards (7/01)